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NATIONAL DAM SAFETY PROGRAM. KEMAH LAKE DAM (NJ00268). DELAWARE--ETC(U)
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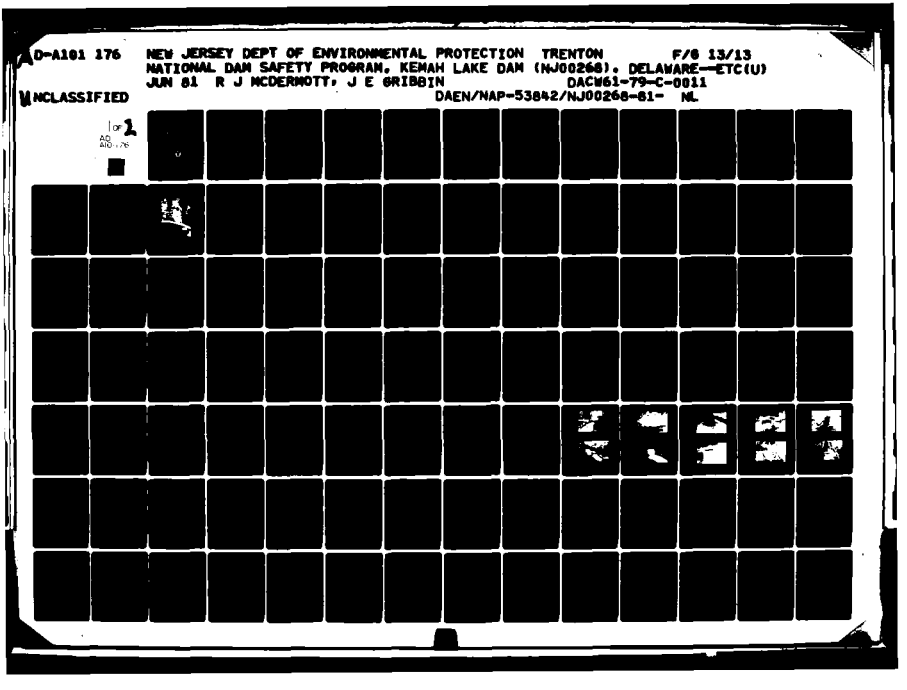

DELAWARE RIVER BASIN
TRIBUTARY TO PAULINS KILL
SUSSEX COUNTY
NEW JERSEY

KEMAH LAKE DAM
NJ00268

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DACW61-79-C-0011

DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

REPT NO. DAEN/NAP-53542/NJ00268-81/06

JUNE 1981

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
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7. AUTHOR(s): McDermott, Richard, PE Gribbon, John PE	8. CONTRACT OR GRANT NUMBER(s): DACW61-79-C-0011
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Storch Engineers 220 Ridgedale Ave Florham Park, NJ 07932	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
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16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams	National Dam Safety Program
Embankments	Kemah Lake Dam, NJ
Visual Inspection	Spillways
Structural Analysis	Erosion

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-N

22 JUN 1981

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Kemah Lake Dam in Sussex County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Kemah Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The spillway is considered seriously inadequate since a flow equivalent to twelve percent of the Probable Maximum Flood (PMF) would cause the dam to be overtopped. The seriously inadequate spillway is assessed as an UNSAFE, non-emergency condition, until more detailed studies prove otherwise or corrective measures are completed. The classification of UNSAFE applied to a dam because of a seriously inadequate spillway is not meant to indicate the same degree of emergency as would be associated with an UNSAFE classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam could take place, significantly increasing the hazard of loss of life downstream from the dam. To ensure adequacy of the structure, the following actions, as a minimum, are recommended.

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures and studies within three months from the date of approval of this report. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around the clock surveillance should be provided.

b. The following remedial measures should be initiated within six months from the date of approval of this report:

(1) Eroded areas on the upstream face of the dam should be properly stabilized.

(2) Trees and adverse vegetation on the downstream side of the roadway berm should be removed.

(3) Bushes causing an obstruction in the entrance to the 48-inch R.C.P. spillway discharge culvert should be removed.

(4) Debris on the downstream side of the roadway berm and in the discharge channel in the vicinity of the dam should be removed.

(5) The ability to drain the lake should be investigated by an engineer experienced in the design and construction of dams. If the need for a low level outlet is determined, a suitable outlet should be designed and installed or the existing outlet should be renovated.

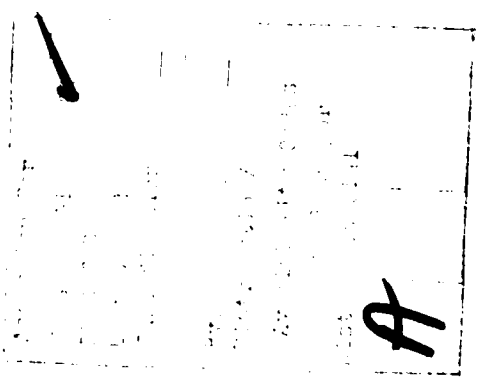
(6) The embankment should be filled in order to establish the dam crest at a minimum of 0.5 foot above the top of the concrete core wall.

(7) Arrangements should be made to monitor the observed seepage at the toe of the dam in order to detect any changes in its condition and its effect on the stability of the dam.

c. The owner of the dam should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Courter of the Thirteenth District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.



NAPEN-N
Honorable Brendan T. Byrne

An important aspect of the Dam Inspection Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

1 Incl
As stated

JAMES G. TON
Colonel, Corps of Engineers
Commander and District Engineer

Copies furnished:
Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Regulation
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

KEMAH LAKE DAM (NJ00268)

C RPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was i spected on 29 December 1980 and 21 March 1981 by Storch Engineers, und contract to the State of New Jersey. The State, under agreement with he U.S. Army Engineer District, Philadelphia, had this inspection per rmed in accordance with the National Dam Inspection Act, Public Law 92- 7.

Kemah Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The spillway is considered seriously inadequate since a flow equivalent to twelve percent of the Probable Maximum Flood (PMF) would cause the dam to be overtopped. The seriously inadequate spillway is assessed as an UNSAFE, non-emergency condition, until more detailed studies prove otherwise or corrective measures are completed. The classification of UNSAFE applied to a dam because of a seriously inadequate spillway is not meant to indicate the same degree of emergency as would be associated with an UNSAFE classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam could take place, significantly increasing the hazard of loss of life downstream from the dam. To ensure adequacy of the structure, the following actions, as a minimum, are recommended.

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures and studies within three months from the date of approval of this report. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around the clock surveillance should be provided.

b. The following remedial measures should be initiated within six months from the date of approval of this report:

(1) Eroded areas on the upstream face of the dam should be properly stabilized.

(2) Trees and adverse vegetation on the downstream side of the roadway berm should be removed.

(3) Bushes causing an obstruction in the entrance to the 48-inch R.C.P. spillway discharge culvert should be removed.

(4) Debris on the downstream side of the roadway berm and in the discharge channel in the vicinity of the dam should be removed.

(5) The ability to drain the lake should be investigated by an engineer experienced in the design and construction of dams. If the need for a low level outlet is determined, a suitable outlet should be designed and installed or the existing outlet should be renovated.

(6) The embankment should be filled in order to establish the dam crest at a mir ıum of 0.5 foot above the top of the concrete core wall.

(7) Ar angements should be made to monitor the observed seepage at the toe of the lam in order to detect any changes in its condition and its effect on the tability of the dam.

c. The ow ır of the dam should develop written operating procedures and a periodic ma' enance plan to ensure the safety of the dam within one year from the date ..f approval of this report.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
Commander and District Engineer

DATE: 17 June 1981

UNSAFE DAM
NATIONAL PROGRAM OF INSPECTION OF DAMS

a. NAME: Kemah Lake Dam

b. ID NO.: NJ00268

c. LOCATION State: New Jersey, County: Sussex.
River or Stream: Tributary of Paulins Kill River
Nearest D/S City or Town: Hampton Township

d. HEIGHT: 17 feet

e. MAXIMUM IMPOUNDMENT CAPACITY: 747 ac. ft.

f. TYPE: Earth Embankment with concrete core wall.

g. OWNER: Kemah Lake Property Owners Association

h. DATE GOVERNOR NOTIFIED OF UNSAFE CONDITIONS: 15 June 1981

i. CONDITION OF DAM RESULTING IN UNSAFE ASSESSMENT: Preliminary report calculations indicate twelve percent of the PMF would overtop the dam.

l. URGENCY CATEGORY: High Hazard, UNSAFE, Non-Emergency.

j. DESCRIPTION OF DANGER INVOLVED: High Hazard potential, overtopping and failure of the dam would significantly increase hazard potential to loss of life and property downstream of dam.

m. EMERGENCY ACTIONS TAKEN:
Gov. notified of this condition by District Engineer's letter of 15 June 1981.

n. REMEDIAL ACTIONS TAKEN:
N.J.D.E.P. will notify dam's owner upon receipt of our letter.

k. RECOMMENDATIONS GIVEN TO GOVERNOR:
Within 30 days of the date of the District Engineer's letter the owner should do the following:
a. Engage the services of a qualified professional consultant to more accurately determine the spillway adequacy by using more detailed and sophisticated hydrologic and hydraulic analyses, and to recommend any remedial measures required to prevent overtopping of the dam.
b. In the interim, a detailed emergency operation plan and downstream warning system should be developed. Also, around the clock surveillance should be provided during periods of unusually heavy precipitation.

o. REMARKS: Final report, to be issued within six weeks, will have WHITE cover.

T.B. HEVERIN, Coordinator
Dam Inspection Program
U.S.A.E.D., Philadelphia

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

NAPEN-N

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, NJ 08621

15 JUN 19[illegible]

Dear Governor Byrne:

This is in reference to our ongoing National Program for Inspection of Non-Federal Dams within the State of New Jersey. Kemah Lake Dam (Federal I.D. No. NJ00268), a high hazard potential structure, has recently been inspected. The dam is owned by the Kemah Lake Property Owners Association, and is located on a tributary of the Paulins Kill River in the Township of Hampton, Sussex County.

Using Corps of Engineers screening criteria, it has been determined that the dam's spillway is seriously inadequate because a flow equivalent to twelve percent of the Probable Maximum Flood would cause the dam to be overtopped. The seriously inadequate spillway is assessed as an UNSAFE, non-emergency condition, until more detailed studies prove otherwise, or corrective measures are completed. The classification of UNSAFE applied to a dam because of a seriously inadequate spillway is not meant to indicate the same degree of emergency as would be associated with an UNSAFE classification applied for a structural deficiency. It does mean, however, that based on an initial screening and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam could take place, significantly increasing the hazard potential to loss of life downstream from the dam. As a result of this UNSAFE determination, it is recommended that the dam's owners take the following measures within 30 days of the date of this letter.

a. Engage the services of a qualified professional consultant to more accurately determine the spillway adequacy by using more detailed and sophisticated hydrologic and hydraulic analyses, and to recommend any remedial measures required to prevent overtopping of the dam.

b. In the interim, a detailed emergency operation plan and downstream warning system should be promptly developed. Also, around the clock surveillance should be provided during periods of unusually heavy precipitation.

A final report on this Phase I inspection will be forwarded to you within two months.

Sincerely,

JAMES G. TON
Colonel, Corps of Engineers
Commander and District Engineer

Copies Furnished:
Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Regulation
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Kemah Lake Dam, NJ00268
State Located:	New Jersey
County Located:	Sussex
Drainage Basin:	Delaware River
Stream:	Tributary to Paulins Kill River
Date of Inspection:	December 29, 1980
	March 21, 1981

Assessment of General Condition of Dam

Based on available records, past operational performance, visual inspection and Phase I engineering analysis, Kemah Lake Dam is assessed as being in fair overall condition.

Hydraulic and hydrologic analyses indicate that the spillway is seriously inadequate. Discharge capacity of the spillway is not sufficient to pass the designated spillway design flood (SDF) without an overtopping of the dam, and dam failure would significantly increase the hazard downstream over that which would exist without dam failure. (The SDF for Kemah Lake Dam is equal to one-half the probable maximum flood.) The spillway is capable of passing approximately 11 percent of the probable maximum flood or 22 percent of the SDF. Therefore, the owner should engage a professional engineer experienced in the design and construction of dams in the near future to perform more accurate hydraulic and hydrologic analyses relating to spillway capacity. Based on the findings of the analyses, the need for and type of remedial measures should be determined and then implemented.

The owner should, soon, develop an emergency action plan together with an effective warning system outlining actions to be taken by the operator to minimize downstream effects of an emergency at the dam.

Arrangements should be be made in the near future to monitor the observed seepage in order to detect any changes in its condition and its effect on the stability of the dam. The monitoring should be performed by a professional engineer experienced in the design and construction of dams.

It is recommended that the following remedial measures be undertaken in the near future:

1) Eroded areas of the upstream face of dam should be properly stabilized.

2) Trees and adverse vegetation on the downstream side of the roadway berm should be removed.

3) Bushes causing obstruction to the entrance to the 48-inch R.C.P. spillway discharge culvert should be removed.

4) Debris on the downstream side of the roadway berm and in the discharge channel in the vicinity of the dam should be removed.

5) The ability to drain the lake should be investigated by an engineer experienced in the design and construction of dams. If the need for a low level outlet is determined, a suitable outlet should be designed and installed or the existing outlet should be renovated.

6) The embankment should be filled in order to establish the dam crest at a minimum of 0.5 foot above the top of the concrete core wall.

In the near future, the owner of the dam should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam.

Richard J. McDermott, P.E.

John E. Gribbin, P.E.

OVERVIEW - KEMAH LAKE DAM

20 JANUARY 1981

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that the unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydraulic and hydrologic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydraulic and hydrologic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

KEMAH LAKE DAM, I.D. NJ00268

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The Division of Water Resources of the New Jersey Department of Environmental Protection (NJDEP) in cooperation with the Philadelphia District of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the State of New Jersey. Storch Engineers has been retained by the NJDEP to inspect and report on a selected group of these dams. The NJDEP is under agreement with the Philadelphia District of the Corps of Engineers.

b. Purpose of Inspection

The visual inspections of Kemah Lake Dam were made on December 29, 1980 and March 21, 1981. The purpose of the inspections was to make a general assessment of the structural integrity and operational adequacy of the dam structure and its appurtenances.

1.2 Description of Project

a. Description of Dam and Appurtenances

The facilities at Kemah Lake Dam consist of an earthfill dam with a concrete corewall and a spillway consisting of a notched concrete weir.

Immediately downstream from the embankment, additional earthfill, comprising a downstream berm supporting a paved roadway, is located. The top width of the embankment is 13 feet while that of the roadway berm is 24 feet. The upstream side of the dam is lined with riprap. The overall length of dam is 240 feet and the height of dam is 16.6 feet.

The spillway consists of a two-stage concrete weir with provision for a stoplog in the notch forming the primary stage. The spillway is located adjacent to the left end of the dam with an earth approach channel upstream and an earth discharge channel and 48-inch R.C.P. discharge culvert downstream. The primary and secondary stages of the spillway are broad crested weirs with effective lengths of 6.0 feet and 16.0 feet, respectively. The secondary spillway crest elevation is 856.3, National Geodetic Vertical Datum (N.G.V.D.), while the elevation of the primary spillway is 855.0, about 2.6 feet below the embankment crest.

The outlet works consist of a low level pipe transversely penetrating the dam. The pipe, a 16-inch C.I.P., is buried by the roadway berm.

b. Location

Kemah Lake Dam is located in the Township of Hampton, Sussex County, New Jersey. Principal access to the dam is by Kemah Lake Drive. Discharge from the spillway of the dam flows into a tributary of the Paulins Kill River.

c. Size and Hazard Classification

The dam is classified in accordance with criteria presented in "Recommended Guidelines for Safety Inspection of Dams" published by the U.S. Army Corps of Engineers. Size categories consist of Small, Intermediate and Large while hazard categories are designated as Low, Significant and High.

Size Classification: Kemah Lake Dam is classified as "Small" size since its maximum storage volume is 747 acre-feet (which is less than 1000 acre-feet) and its height is 16.6 feet (which is less than 40 feet).

Hazard Classification: Visual inspection of the downstream flood plain of the dam together with breach analysis indicate that failure of the dam due to overtopping could cause inundation of approximately 7 dwellings located adjacent to a small lake located 9100 feet downstream from the dam. Loss of more than a few lives is possible. Accordingly, Kemah Lake Dam is classified as "High" Hazard.

d. Ownership

Kemah Lake Dam is owned by the Kemah Lake Property Owners Association, R.D. 8, Newton, N.J. 07860.

e. Purpose of Dam

The purpose of the dam is the impoundment of a recreational lake facility.

f. Design and Construction History

The dam was designed in 1927 by the firm of Snook & Hardin of Newton, N.J. Construction took place during the years 1927 and 1928. Documentation of inspections by the State of New

Jersey during construction operations is available in the files of the NJDEP, Division of Water Resources.

g. Normal Operational Procedure

Reportedly, the lake level is varied 18 inches on a yearly basis by removing a stoplog in the spillway in the Fall and then replacing it in the Spring.

Maintenance of Kemah Lake Dam reportedly is performed by the Kemah Lake Property Owners Association. Reportedly, no regular maintenance schedule is used.

1.3 Pertinent Data

a. Drainage Area	1.3 square miles
b. Discharge at Damsite	
Maximum flood at damsite	Unknown
Outlet works at normal pool elevation	N.A.
Spillway capacity at top of dam	101 c.f.s.
c. Elevation (N.G.V.D.)	
Top of Dam	857.6
Maximum pool - design flood	859.2
Principal spillway crest	855.0
Secondary spillway crest	856.3
Streambed at center line on dam	841.1
Maximum tailwater	843 (Estimated)

d. Reservoir Length

Length of design surcharge	4100 feet (Estimated)
Length of normal pool	3800 feet (Scaled)

e. Storage (Acre-feet)

SDF maximum stage	926
Normal pool	608
Top of dam	747

f. Reservoir Surface (acres)

SDF maximum stage	103.0 (Estimated)
Normal pool	101.5 (Estimated)
Top of dam	103.0 (Estimated)

g. Dam

Type	Earthfill
Length	240 feet
Height	16.6 feet
Sideslopes - Upstream	1 horiz. to 1 vert.
- Downstream	1 horiz. to 1 vert.
Zoning	Unknown
Impervious core	Concrete Core Wall
Grout curtain	Unknown

h. Diversion and Regulating Tunnel N.A.

i. Spillway

Type	Concrete Weir
Length of weir - Primary	6.0 feet
- Secondary	16.0 feet
Crest elevation - Primary	855.0
- Secondary	856.3
Approach channel	Earth Channel
Discharge channel	Earth channel discharging into 48" C.M.P.

j. Regulating outlet

Gated 16-inch CIP (Inoperable: Buried by addition to embankment fill)

SECTION 2: ENGINEERING DATA

2.1 Design

Construction drawings titled "Proposed Myrtle Grove Dam" prepared by Snook & Hardin, Engineers, for Ernest Roe & D. Struble, dated January 1927, are available in the files of the NJDEP, Division of Water Resources.

In addition, hydraulic/hydrologic design calculations are contained in the NJDEP file and are summarized as follows:

The spillway was designed as a 60-foot long weir with discharge coefficient of 3.0 and 1.5 feet vertical distance from spillway crest to dam crest. With 1 foot head, outflow was found to be 120 sec.- ft./per square mile of drainage basin which was considered sufficient.

2.2 Construction

Kemah Lake Dam was constructed in 1927 and 1928 by F.W. Schwiers of New York, N.Y. Five inspections were performed by the State of New Jersey during and after construction operations. According to the final inspection report, construction had been completed in accordance with the approved plans and was accepted.

It was noted in one of the inspection reports that although no seepage was observed, the impoundment was filling at an unexpectedly slow rate.

In addition, three monthly progress reports and photos of the dam are contained in the NJDEP file.

2.3 Operation

Correspondence in the NJDEP file indicates concern about possible effects of Hurricane Diane in 1955. Reportedly, in 1949 or 1950, the spillway wall was raised causing a rise in lake water level of about 18 inches. The question was raised whether or not the additional hydrostatic pressure would endanger the stability of the dam.

In response to the questions raised, the State inspected the dam in September 1955 and issued a report in October 1955. According to the report, unapproved modifications had been made since construction in 1928 and the Kemah Lake Corporation was directed to rectify the unacceptable conditions. Recommendations for remedial modifications were made as follows:

1) The spillway weir should be modified to be 20 feet long and minimum 2.5 feet below the dam crest.
2) Fill should be added to the spillway crest to bring the crest level a minimum 0.5 foot above the top of the concrete core wall.
3) The top width of the embankment should be a minimum of 8 feet.
4) Trees and adverse vegetation should be removed from the embankment.
5) Provisions should be made to dewater the lake when required.

The inspection report also noted that the riprap had slipped below the upper elevation shown on the construction drawings. The report further noted that the dam had been barely overtopped by the 1955 flood and that further overtopping was prevented by outflow over a natural saddle along the lake observed to be 0.5 foot to 1.0 foot above normal lake level.

An inspection made by W.J. Hardin in 1968 indicated that the low level outlet pipe had not been operated for a number of years and its location was not known. The inspection report recommended

repairs to the spillway which was observed to be cracked. (The spillway was subsequently reconstructed.) The report also indicated that no seepage was observed.

2.4 Evaluation

a. Availability

Available engineering information is limited to that which is on file with the NJDEP.

b. Adequacy

The NJDEP file information was of significant assistance in the performance of a Phase I evaluation. However, complete information needed to properly evaluate the dam was not available. A list of absent information is included in paragraph 7.1.b.

c. Validity

The available hydraulic analyses appear to be valid with respect to engineering practice generally accepted in 1927. However, they are not valid according to analytic procedures developed by the Corps of Engineers for the present inspection and assessment program.

The assessment of conditions at the dam made by the State of New Jersey in 1955 is in close agreement with the results of analyses made in connection with this Phase I Report, assuming on SDF equivalent to the 100-year storm. Hydraulic and hydrologic analyses indicate that if the spillway crest remained 2.6 feet below the dam crest (reportedly the current practice during winter months) as recommended in the 1955 inspection report, the dam would not be overtopped by a storm equivalent to the

100-year storm. However, the choice of 1/2 PMF as design flood in accordance with guidelines established by the U.S. Army Corps of Engineers renders the assessment and recommendations of 1955 inadequate.

Inspections made in connection with this report disclosed that the spillway crest length is greater than 20 feet as recommended in the 1955 inspection report, that the embankment crest is flush with the top of the concrete core wall as observed in 1955 and that the riprap is below the top of the embankment as observed in 1955.

Also, inspection of the north end of the lake indicated that an irregularly shaped saddle is located in that area. Although measuresments were difficult, the height above normal water level appeared to be greater than the 0.5 foot to 1.0 foot reported in 1955; the greater height possibly due to subsequent development.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

Kemah Lake Dam was inspected on December 29, 1980 and March 21, 1981 by members of the staff of Storch Engineers. A copy of the visual inspection checklist is contained in Appendix 1. The following procedures were employed for the inspection:

1) The embankment of the dam, appurtenant structures and adjacent areas were examined.
2) The embankment and accessible appurtenant structures were measured and key elevations were determined by surveyor's level.
3) The embankment, appurtenant structures and adjacent areas were photographed.
4) The downstream flood plain was toured to evaluate downstream development and restricting structures.

b. Dam

The roadway pavement was in satisfactory condition. The concrete core wall was observed to be flush with the crest of dam and exposed for a distance of about 50 feet.

The original embankment, upstream from the roadway, was generally grass covered and was eroded on its upstream face above the observed riprap. The riprap was composed of stones ranging in size from 6 inches to 30 inches. The riprap appeared to provide adequate protection to the area in which it was located.

The downstream side of the roadway berm was overgrown with bushes and weeds and trees. The trees ranged in size from 2 inches to 18 inches. Also, the downstream side of the dam was very irregular in shape and appeared to have been filled in order to provide a small parking area. At the downstream end of the fill area there were large accumulations of branches and various debris which had been dumped over the side. The earth embankment just upstream from the roadway is covered with weeds on the downstream side.

c. Appurtenant Structures

The concrete notched weir was in satisfactory condition and the stoplog was not in place. The approach and discharge channels were in generally satisfactory condition. The spillway discharge culvert appeared to be in satisfactory condition. The stone rubble headwalls at each end of the culvert appeared to be in satisfactory condition. The entrance to the culvert was significantly overgrown by bushes. The low level outlet pipe could not be observed at the toe of the roadway berm. However, a stream of water containing orange colored deposits, flowing with a trickle, was observed at the approximate location of the outlet pipe. No operating mechanism was observed.

d. Downstream Channel

The downstream channel consists of a natural stream with a bottom lined with cobbles and boulders and wooded banks and flood plain. It has steep banks on each side resembling a glen. Obstructions in the form of debris were noted in the channel.

e. Reservoir Area

The reservoir is surrounded almost entirely by homesites. The shore slopes are very steep, approximately 50 percent or more. The home sites are partially wooded and some are accompanied by lake related facilities such as walls and docks.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

The level of water in Kemah Lake is regulated by discharge over the concrete spillway located adjacent to the left end of the dam. Reportedly, the steel stoplog is removed from the notch during winter months to maintain the lake level 18 inches lower than the level maintained during summer months. The outlet works of the dam is currently inoperable and cannot be used to drain the lake or to augment the discharge capacity of the spillway.

4.2 Maintenance of the Dam

Reportedly, maintenance is performed only on an "as needed" basis.

4.3 Maintenance of Operating Facilities

Reportedly, there is no program of regular maintenance of the operating facilities.

4.4 Description of Warning System

Reportedly, no formal warning system is in use at the present time.

4.5 Evaluation of Operational Adequacy

The operation of the dam has been adequate to the extent that the dam reportedly has never been overtopped.

Maintenance documentation is poor and maintenance has been inadequate in the following areas:

1) Trees and brush on downstream side of roadway berm not removed.

2) Debris on downstream side of roadway berm and in spillway discharge channel not removed.
3) Outlet works not restored to operational condition.
4) Bushes at entrance to spillway discharge culvert not removed.
5) Erosion on upstream side of embankment not repaired.
6) Crest of embankment not filled minimum 0.5 foot above concrete core wall.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

The quantity of storm water runoff that the spillway should be able to handle is based on the size and hazard classification of the dam. This runoff quantity, called the spillway design flood (SDF), is described in terms of return frequency or probable maximum flood (PMF) depending on the extent of the dam's size and potential hazard. According to the "Recommended Guidelines for Safety Inspection of Dams" published by the U.S. Army Corps of Engineers, the SDF for Kemah Lake Dam falls in a range of 1/2 PMF to PMF. In this case, the low end of the range, 1/2 PMF, is chosen since the factors used to select size and hazard classification are on the low side of their respective ranges.

The SDF inflow hydrograph for Kemah Lake Dam (See Appendix 4) was calculated by the Soil Conservation Service Triangular Unit hydrograph method with the curvilinear transformation utilizing the HEC-1-DAM computer program.

General hydrologic characteristics used in this method were computed using USGS quadrangles. The drainage area contributing to the impoundment is 1.3 square miles. Most of the watershed is suburban and farm land. The SDF peak inflow was computed to be 2383 c.f.s.

The spillway discharge rates were computed by the use of a weir formula appropriate for the configuration of the spillway. Discharge rates were computed for two operational conditions: stoplog in place and stoplog pulled. The total spillway discharge with lake level equal to the top of the dam was

computed to be 101 c.f.s.with the stoplog in place and 120 c.f.s. with the stoplog pulled. The SDF was routed through the dam by use of the HEC-1-DAM computer program using the modified Puls Method. In routing the SDF, it was found that the dam crest would be overtopped by a depth of 1.6 feet with the stoplog in place.

A dam breach analysis was then performed using a trapezoidal breach section with bottom length of 75 feet and sideslopes of 1 horizontal to 1 vertical. The breach peak outflow was computed to be 12964 c.f.s. Dam breach computations are contained in Appendix 4.

The breach analysis indicates that dam failure from overtopping could cause inundation of approximately 7 dwellings located along a small lake 9100 feet downstream from the dam. The analysis indicates that failure of the dam would significantly increase the hazard to loss of life downstream over that which would exist without failure. Accordingly, the subject spillway is assessed as being seriously inadequate in accordance with criteria developed by the U.S. Army Corps of Engineers.

b. Experience Data

Reportedly Kemah Lake Dam experienced overtopping once since construction in 1928. The overtopping occurred during the flood of 1955 when the crest was barely overtopped.

c. Visual Observation

At the time of the field inspections there was no evidence of recent overtopping.

d. Overtopping Potential

As indicated in paragraph 5.1.a. a storm of magnitude equal to the SDF would cause overtopping of the dam to a depth of 1.6 feet over the crest of the dam. The spillway is capable of passing approximately 11 percent of the PMF or 22 percent of the SDF with the lake level equal to the crest of dam.

e. Drawdown Data

Drawdown of the lake below the primary crest elevation of the spillway cannot be accomplished due to the inoperable condition of the outlet works.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observation

The dam appeared, at the time of inspection to be outwardly structurally sound with no evidence of embankment cracks or distress. Evidence of seepage was observed at one location along the toe of dam, but did not appear to be an indication of immediate distress in the embankment. Since seepage was not reported as a result of an inspection in 1968, the observed seepage may be a relatively recent development and may be a result of recently formed seepage paths along the abandoned outlet pipe.

b. Generalized Soils Description

The soil at Kemah Lake Dam site is characterized by the ground Moraine formation deposited during the Wisconsin Glacial stage. This accumulation surrounds the lake except on the North, where the lake is bounded by glacial recessional moraine deposits.

The ground moraine, a conglomerate of silt, sand and boulders is underlaid by shale and sandstone. Many large boulders of quartizite with considerable sandstone and shale fragments are included in the recessional moraine profile. The Martinsburg shale, as shown on the Geologic Map of New Jersey extends presumably below the dam foundation.

c. Design and Construction Data

The analysis of structural stability and construction data for the embankments are not available.

d. Operating Records

Operating records for the dam and appurtenances are not available.

e. Post Construction Changes

Reportedly, the spillway wall was raised in or about 1950 resulting in a rise in lake level of 18 inches. Also additional embankment fill was placed on the downstream side of the original embankment to facilitate construction of a paved roadway. The fill apparently buried the low level outlet pipe and operating mechanism.

In addition, the natural saddle at the north end of the lake may have been raised as a result of residential development resulting in reduced outflow from the lake during times of high water level.

f. Seismic Stability

Kemah Lake Dam is located in Seismic Zone 1 as defined in "Recommended Guidelines for Safety Inspection of Dams," which is a zone of very low seismic activity. Experience indicates that dams in Seismic Zone 1 will have adequate stability under seismic loading conditions, if stable under static loading conditions. The dam appeared to be stable under static loading conditions at the times of inspection.

SECTION 7: ASSESSMENT AND RECOMMENDATIONS

7.1 Dam Assessment

a. Safety

Based on the hydraulic and hydrologic analyses outlined in Section 5 and Appendix 4, the spillway of Kemah Lake Dam is assessed as being seriously inadequate. The spillway is not able to pass the SDF without an overtopping of the dam when the stoplog is in place.

The embankment appeared at the time of inspection, to be generally outwardly stable. Observed seepage at the toe was not considered to be evidence of immediate dam instability. However, the seepage could be the result of relatively recent development of seepage paths along the buried low level outlet pipe. Therefore, the seepage could possible endanger embankment stability if corrective measures are not taken.

b. Adequacy of Information

Information sources for this study included: 1) field investigations, 2) data from the NJDEP file (dam inspection reports, correspondence and computations), 3) original construction drawings for the dam, 4) USGS quadrangles and 5) consultation with members of the Kemah Lake Property Owners Association. The information is adequate for a Phase I Assessment as outlined in "Recommended Guidelines for Safety Inspection of Dams."

c. Necessity for Additional Data/Evaluation

The data available and the evaluations performed are considered to be sufficient to permit a Phase I assessment of Kemah Lake Dam.

7.2 Recommendations

a. Remedial Measures

Based on hydraulic and hydrologic analyses outlined in paragraph 5.1.a, the spillway is considered to be seriously inadequate. It is therefore recommended that a professional engineer experienced in the design and construction of dams be engaged in the near future to perform more accurate hydraulic and hydrologic analyses relating to spillway capacity. Based on the findings of these analyses, the need for and type of remedial measures should be determined and then implemented.

The owner should, soon, develop an emergency action plan together with an effective warning system outlining actions to be taken by the operator to minimize downstream effects of an emergency at the dam.

In addition, it is recommended that the following remedial measures be undertaken in the near future:

1) Eroded areas of the upstream face of dam should be properly stabilized.

2) Trees and adverse vegetation on the downstream side of the roadway berm should be removed.

3) Bushes causing obstruction to the entrance to the 48-inch R.C.P. spillway discharge culvert should be removed.

4) Debris on the downstream side of the roadway berm and in the discharge channel in the vicinity of the dam should be removed.

5) The ability to drain the lake should be investigated by an engineer experienced in the design and construction of dams. If the need for a low level outlet is determined, a suitable outlet should be designed and installed or the existing outlet should be renovated.

6) The embankment should be filled in order to establish the dam crest at a minimum of 0.5 foot above the top of the concrete core wall.

b. Maintenance

In the near future, the owner of the dam should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam.

c. Additional Studies

Arrangements should be made in the near future to monitor the observed seepage in order to detect any changes in its condition and its effect on the stability of the dam. The monitoring should be performed by a professional engineer experienced in the design and construction of dams.

PLATES

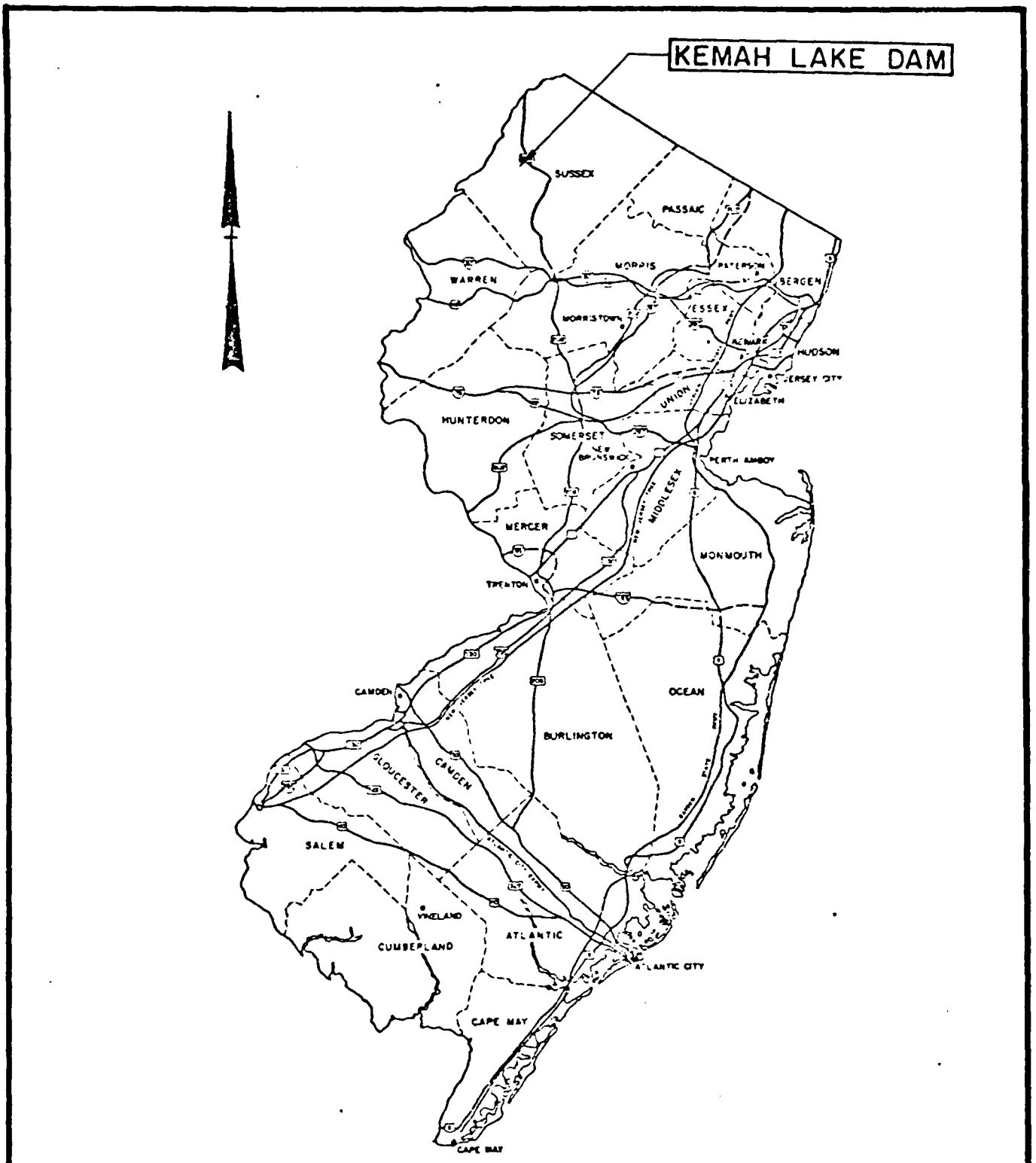
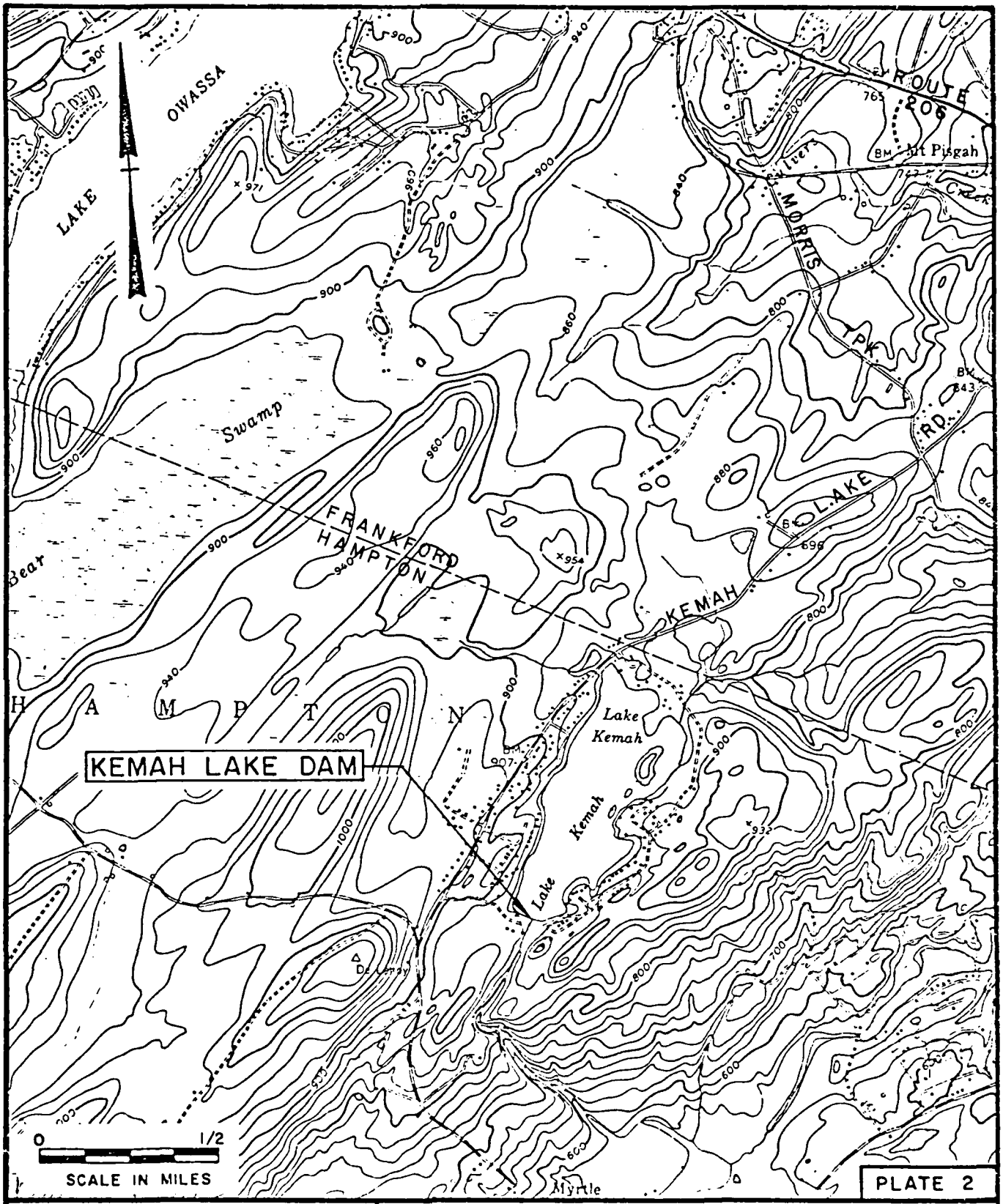


PLATE 1

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS KEY MAP KEMAH LAKE DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	SCALE: NONE DATE: FEB. 1981



STORCH ENGINEERS
FLORHAM PARK, NEW JERSEY

DIVISION OF WATER RESOURCES
N.J. DEPT. OF ENVIR. PROTECTION
TRENTON, NEW JERSEY

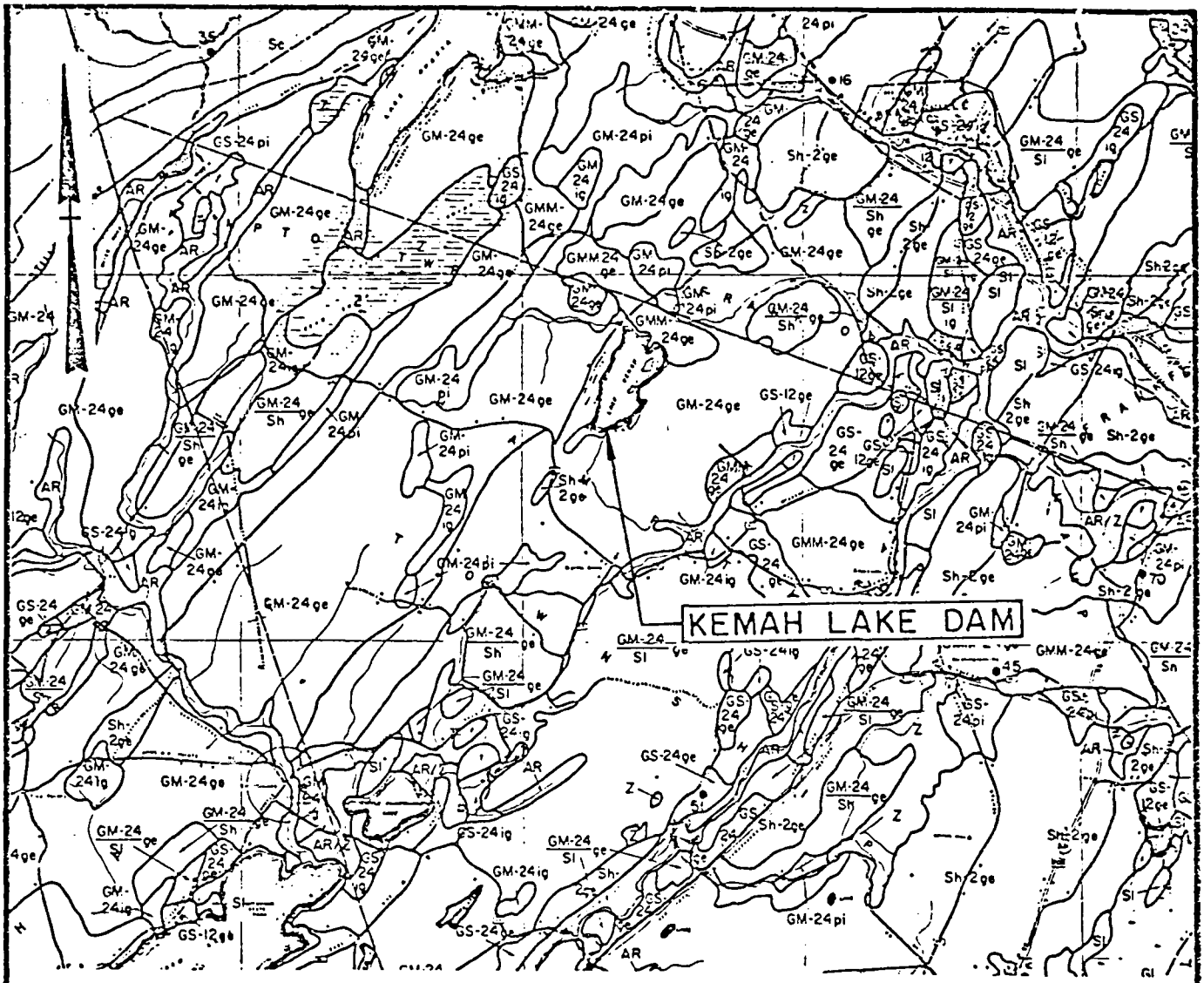
INSPECTION AND EVALUATION OF DAMS

VICINITY MAP

KEMAH LAKE DAM

SCALE: AS SHOWN

DATE: FEB. 1981



Legend

GM-24 Glacial ground moraine.
Composed of unconsolidated unstratified material deposited during the Wisconsin glacial stage.

Sh-2 Slate and shale bedrock of Ordovician age.
Shown as the Martinsburg shale on the Geologic Map of New Jersey.

Note: Information taken from Rutgers University, Soil Survey of New Jersey, Report No. 11, Sussex County, November 1953 and Geologic Map of New Jersey prepared by J.V. Lewis and H. Kummel 1910-1912, revised by H. B. Kummel 1931 and M. Johnson 1950.

PLATE 3

STORCH ENGINEERS
FLORHAM PARK, NEW JERSEY.

DIVISION OF WATER RESOURCES
N.J. DEPT. OF ENVIR. PROTECTION
TRENTON, NEW JERSEY.

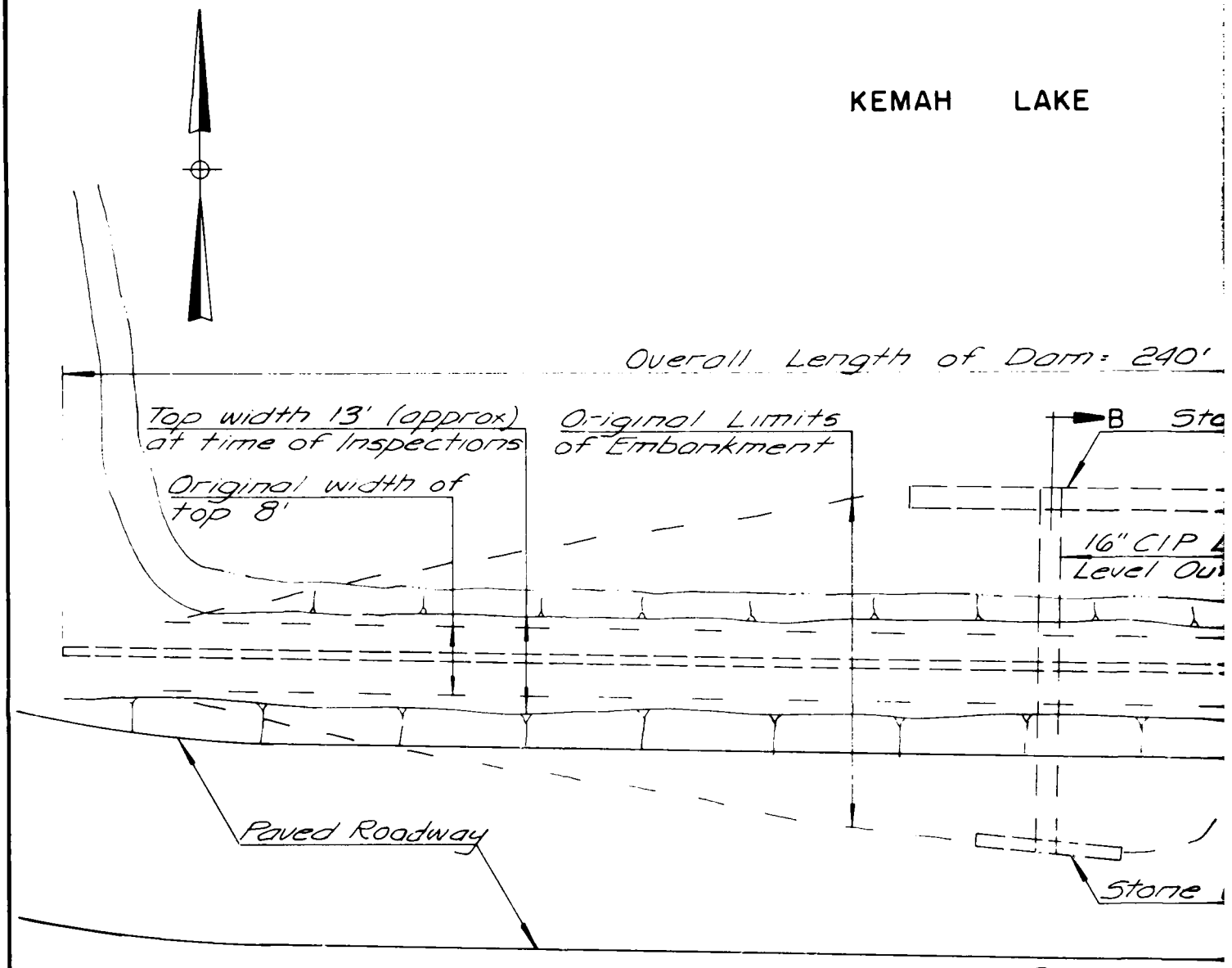
INSPECTION AND EVALUATION OF DAMS

SOIL MAP

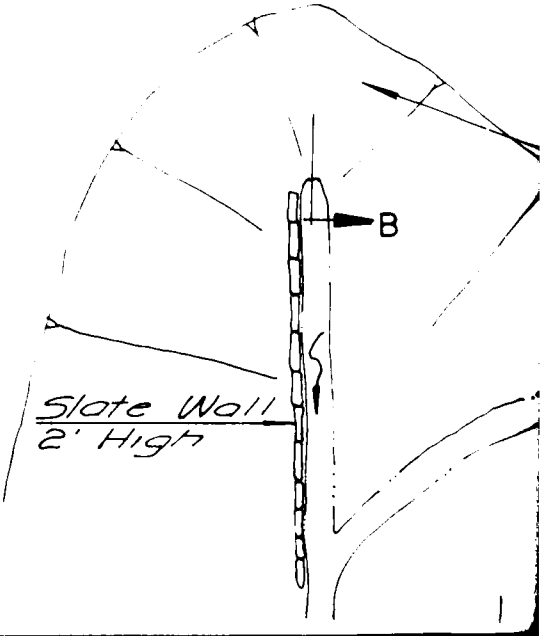
KEMAH LAKE DAM

SCALE: NONE

DATE: FEB. 1981



Note Information taken from drawings titled "Proposed Myrtle Grove Dam" prepared by Snook & Hardin, dated January 1927 and Field Inspections December 19, 1980 and March 21, 1981.



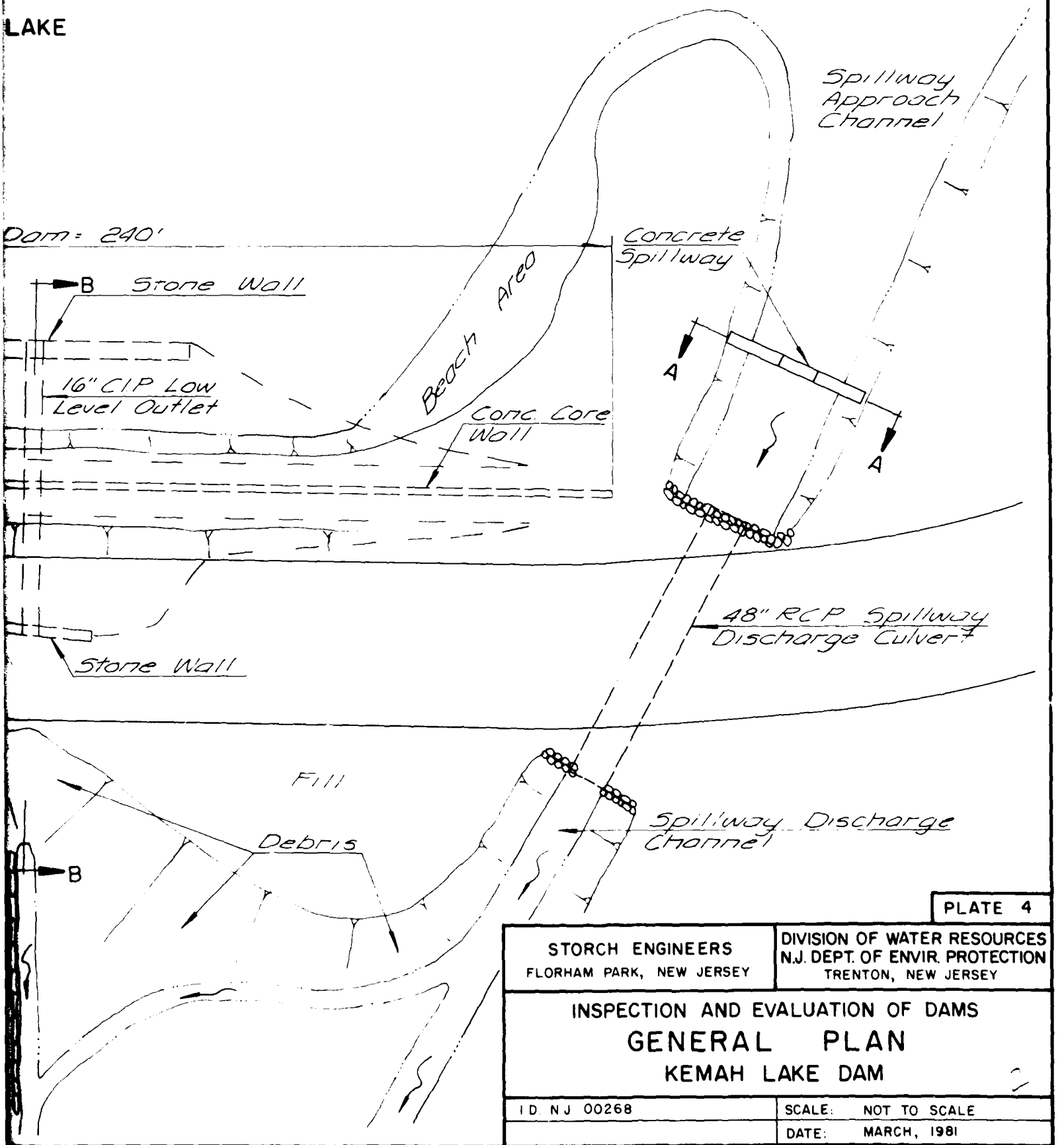


PLATE 4

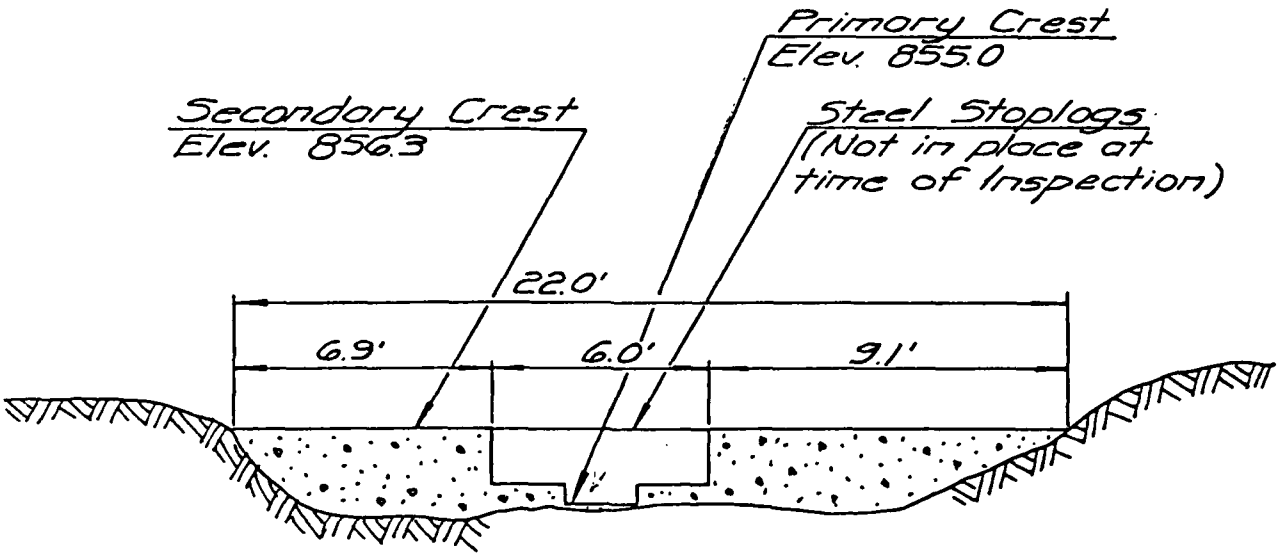
STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

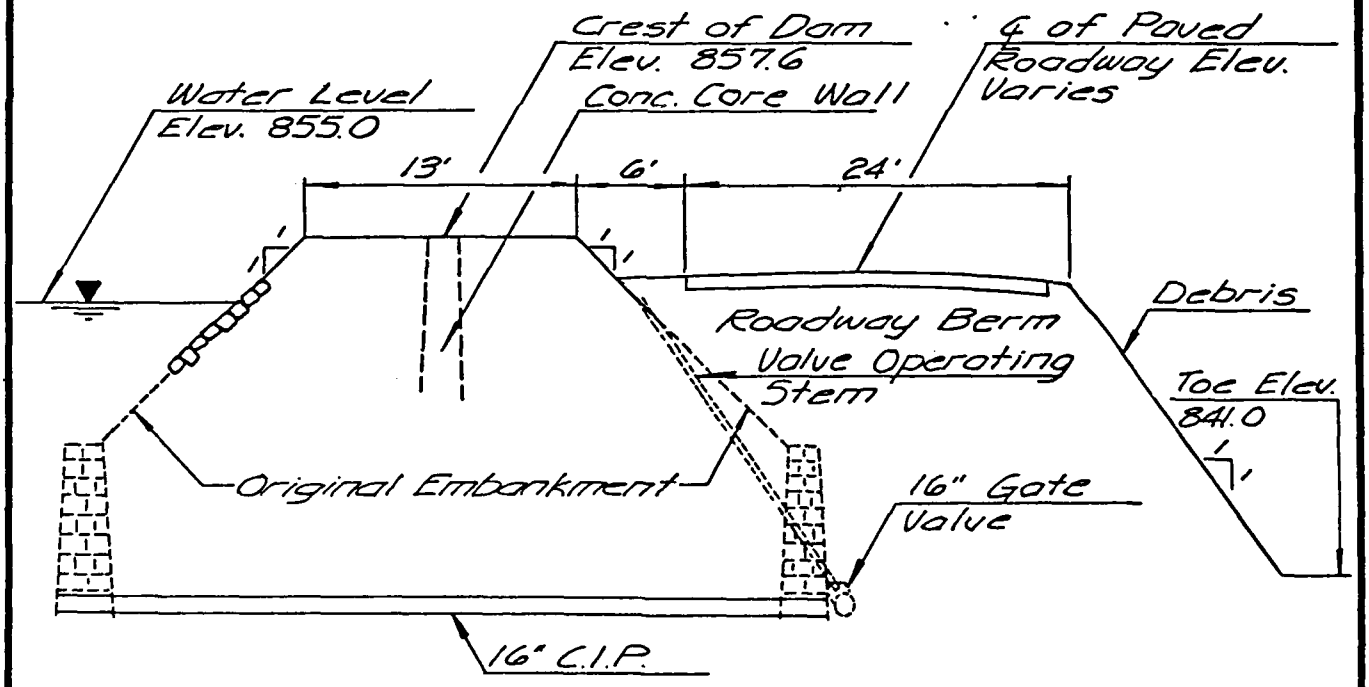
GENERAL PLAN

KEMAH LAKE DAM

I.D. NJ 00268	SCALE: NOT TO SCALE
	DATE: MARCH, 1981



SECTION A-A

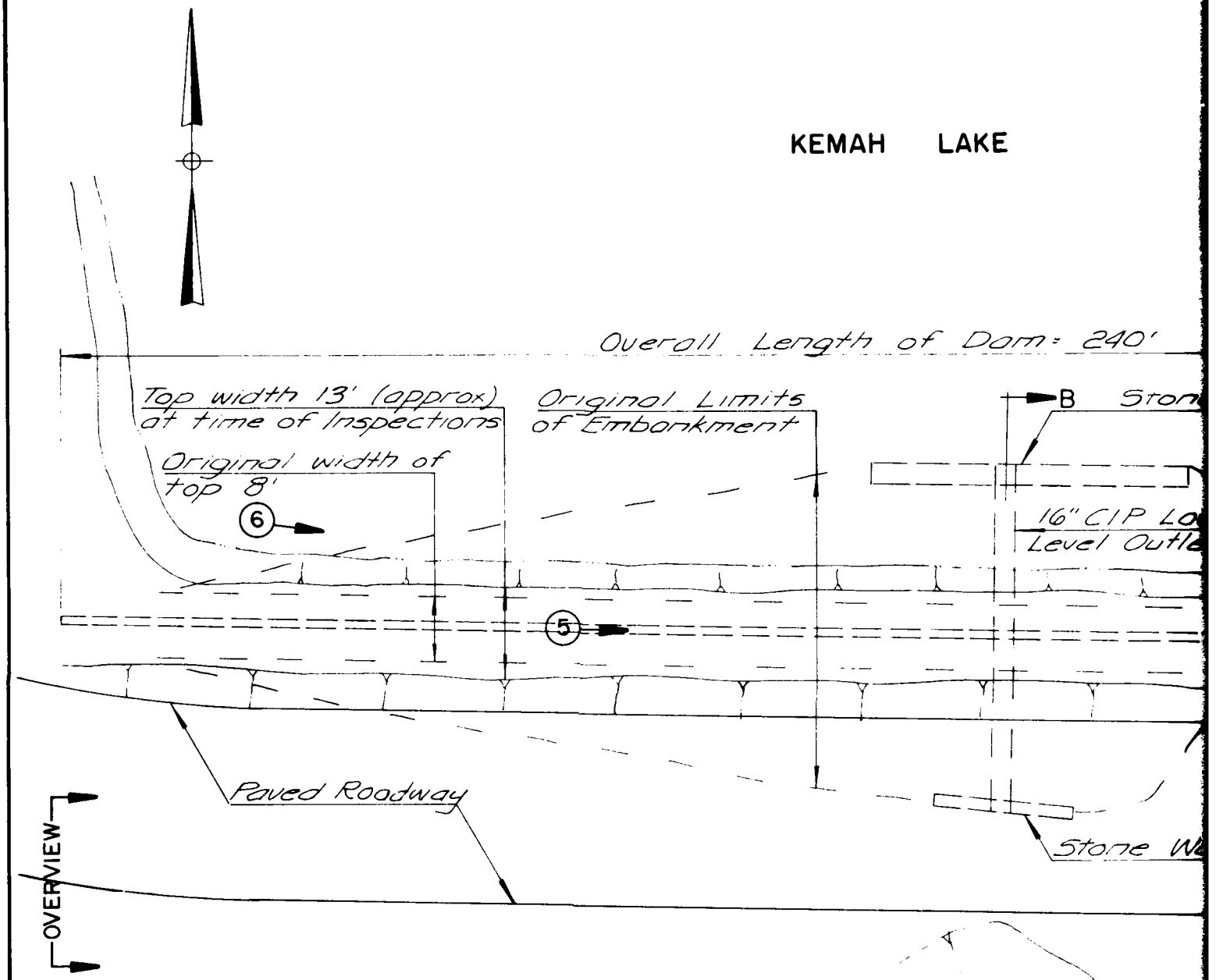


See Note 1
Plate #4

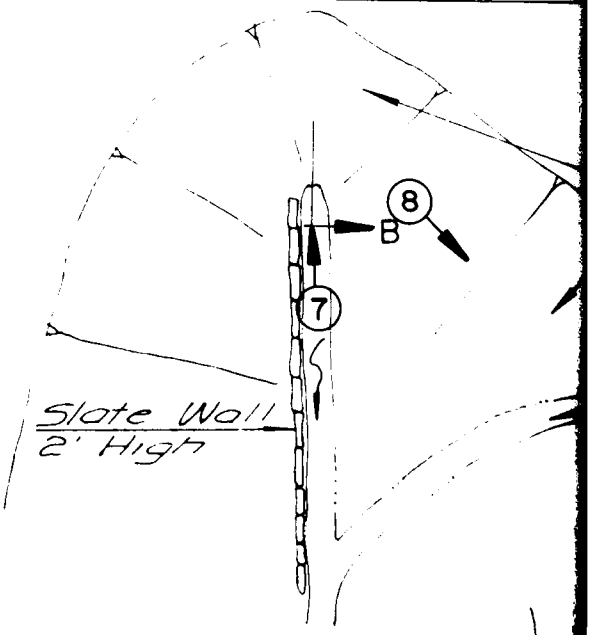
SECTION B-B

PLATE 5

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS SECTIONS KEMAH LAKE DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00268 — SCALE: NONE DATE: MARCH, 1981



Note Information taken from drawings titled "Proposed Myrtle Grove Dam" prepared by Snook & Hardin, dated January 1927 and Field Inspections December 19, 1980 and March 21, 1981.



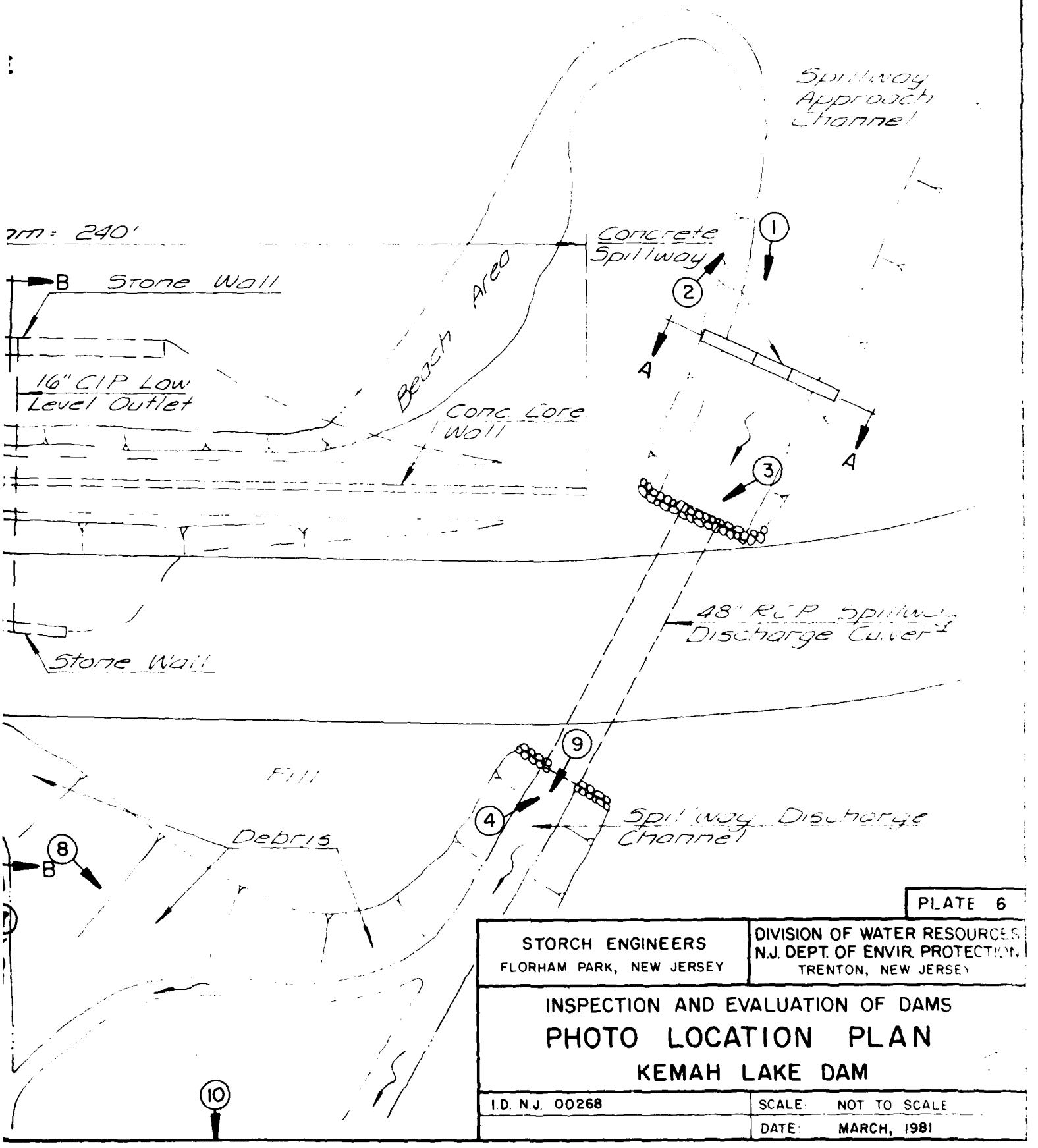


PLATE 6

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

PHOTO LOCATION PLAN

KEMAH LAKE DAM

I.D. N.J. 00268	SCALE: NOT TO SCALE
	DATE: MARCH, 1981

APPENDIX 1

Check List - Visual Inspection

Check List - Engineering Data

Check List

Visual Inspection

Phase I

Name of Dam Kemah Lake Dam County Sussex State N.J. Coordinators NJDEP

Date(s) Inspection 12/19/80, 3/21/81 Weather Cloudy Temperature 35°F

Pool Elevation at time of Inspection 855.0 M.S.L. Tailwater at Time of Inspection 841.0 M.S.L.

Inspection Personnel:

John Gribbin — Mark Brady —

Charles Osterkorn — Richard McDermott —

Daniel Buckelew

John Gribbin Recorder

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GENERAL	Pavement of road downstream from original embankment in satisfactory condition. Original embankment covered with grass and weeds. Downstream face of road berm covered with bushes, weeds, trees (2" to 18") and loose fill and debris.	Road berm added to downstream side of embankment subsequent to original construction.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Appeared sound.	
ANY NOTICEABLE SEEPAGE	Standing water with orange colored deposits observed at toe in approx. location of outlet works. Water flowing with a trickle.	Seepage should be monitored.
STAFF GAGE AND RECORDER	None observed.	
DRAINS	Storm drain under roadway in approx. location of outlet works. No toe drain observed.	

EMBANKMENT

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	Toe obscured by vegetation and debris.
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Erosion observed on upstream side above riprap.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Vertical: Original embankment level. Road berm varies approx. 3' Horizontal: Original embankment straight. Road berm irregular.	
RIPRAP	Riprap on upstream face 6" to 30" diameter. Coverage appeared satisfactory. Riprap not present on upper 2' of embankment.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SURFACES IN OUTLET CONDUIT	None observed	Reportedly, outlet works burried by addition of road berm.
INTAKE STRUCTURE	None observed	
OUTLET STRUCTURE	None observed	
OUTLET CHANNEL	None observed	
GATE AND GATE HOUSING	None observed	

SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
WEIR	Concrete surfaces appeared satisfactory. Stoplogs not in place at times of inspection.	
APPROACH CHANNEL	Earth channel in generally satisfactory condition.	
DISCHARGE CULVERT	48-inch RCP in satisfactory condition. Stone rubble headwalls at each end in satisfactory condition.	
DISCHARGE CHANNEL	Straight channel downstream from culvert. Left side formed by shale outcrop, right side formed by earth.	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	Not available	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Shore slopes steep, 50% or greater. Shores contain partially wooded homesites.	
SEDIMENTATION	Unknown	
STRUCTURES ALONG BANKS	Lake surrounded by homesites, many of which have lake related structures such as walls and docks.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTION, DEBRIS, ETC.)	Natural stream with bottom lined with cobbles and boulders and wooded to its waterline. Significant amount of debris observed in channel.	
SLOPES	Slopes adjacent to channel are high and steep. Flood plain resembled a glen.	
STRUCTURES ALONG BANKS	Two dwellings adjacent to channel at dam. Dwellings above elevation of crest. Approx. 10 dwellings located along lake 9100 feet from dam.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM			REMARKS
DAM	-	PLAN	Construction drawings titled "Proposed Myrtle Grove Dam" prepared by Snook & Hardin for Ernest Roe & D.Struble, dated January 1927 available in NJDEP files
		SECTIONS	
SPILLWAY	-	PLAN	Available: Snook & Hardin drawings
		SECTIONS	
		DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS			Not available
OUTLETS	-	PLAN	Not available
		DETAILS	
		CONSTRAINTS	
		DISCHARGE RATINGS	
HYDRAULIC/HYDROLOGIC DATA			Available. Calculations in NJDEP file
RAINFALL/RESERVOIR RECORDS			Not available
CONSTRUCTION HISTORY			Available in NJDEP file
LOCATION MAP			Available in NJDEP file

ITEM	REMARKS
DESIGN REPORTS	Not available
GEOLOGY REPORTS	Not available
DESIGN COMPUTATIONS	Spillway capacity computations in NJDEP file
HYDROLOGY & HYDRAULICS	
DAM INSTABILITY	Not available
SEEPAGE STUDIES	Not available
MATERIALS INVESTIGATIONS	Not available
BORING RECORDS	
LABORATORY	
FIELD	
POST-CONSTRUCTION SURVEYS OF DAM	Not available
BORROW SOURCES	Not available

ITEM	REMARKS
MONITORING SYSTEMS	Not available
MODIFICATIONS	Correspondence in NJDEP file refers to modification of original spillway to raise lake level approx. 1.5' and addition of fill on downstream side of dam to construct roadway.
HIGH POOL RECORDS	Correspondence in NJDEP file refers to 1955 hurricane during which dam was barely overtopped.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Inspection report in 1955 by State of New Jersey assessed unapproved modifications and made recommendations for remedial measures.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	No accidents or failure but correspondence in NJDEP file refers to concern over the safety of the dam following the 1955 flooding.
MAINTENANCE OPERATION RECORDS	Not available.

APPENDIX 2

Photographs

PHOTO 1

CONCRETE NOTCHED WEIR COMPRISING SPILLWAY

PHOTO 2

SPILLWAY APPROACH CHANNEL

PHOTO 3

INTAKE END OF SPILLWAY DISCHARGE CULVERT

PHOTO 4

OUTLET END OF SPILLWAY DISCHARGE CULVERT

PHOTO 5
CREST OF DAM

PHOTO 6
UPSTREAM FACE OF DAM

KEMAH LAKE DAM
21 MARCH 1981

PHOTO 7

SEEPAGE AT TOE OF DAM - APPROX. LOCATION OF OUTLET WORKS

PHOTO 8

DEBRIS ON DOWNSTREAM SIDE OF DAM

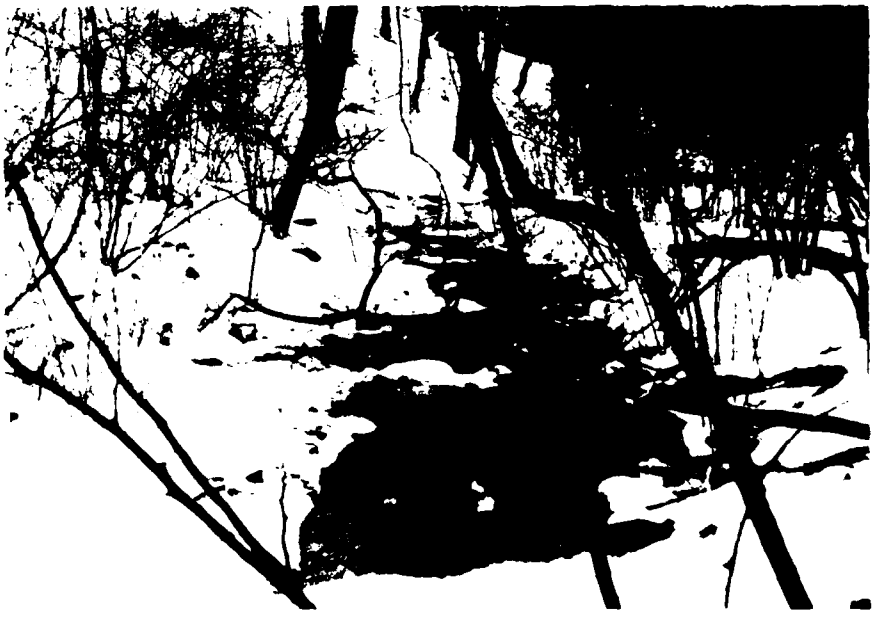
KEMAH LAKE DAM

21 MARCH 1981

21 MARCH 1981

PHOTO 9

DISCHARGE CHANNEL DOWNSTREAM FROM 48-INCH CULVERT



29 DECEMBER 1980

PHOTO 10

DOWNSTREAM CHANNEL

APPENDIX 3

Engineering Data

CHECK LIST

HYDROLOGIC AND HYDRAULIC DATA

ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Wooded, Hilly

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 856.3 (608 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N.A.

ELEVATION MAXIMUM DESIGN POOL: 859.2

ELEVATION TOP DAM: 857.6

SPILLWAY CREST: 2-Stage Weir

a. Elevation 855.0 (Primary), 856.3 (Secondary)

b. Type Broad Crested Weir with Notch

c. Width 1.5 feet

d. Length 6 Feet (Primary), 16 Feet (Secondary)

e. Location Spillover Adjacent to Left End of Dam

f. Number and Type of Gates One Steel Stoplog

OUTLET WORKS:

a. Type Gated 16-inch CIP

b. Location Center of Dam (buried by additional fill)

c. Entrance Invert unknown

d. Exit Invert unknown

e. Emergency Draindown Facilities: Outlet not functional

HYDOMETEOROLOGICAL GAGES: None

a. Type N.A.

b. Location N.A.

c. Records N.A.

MAXIMUM NON-DAMAGING DISCHARGE:

(Lake Stage Equal to Top of Dam) 101 c.f.s.

APPENDIX 4

Hydraulic/Hydrologic Computations

STORCH ENGINEERS

Project KEMAH LAKE DAM

Sheet 1 of 12

Made By CLO Date 1/17/81

Chkd By JG Date 3/23/81

HYDROLOGY

HYDROLOGIC ANALYSIS - RUNOFF HYDROGRAPH WILL BE DEVELOPED BY THE HEC-1-DAM COMPUTER PROGRAM USING THE SCS TRIANGULAR HYDROGRAPH WITH CURVILINEAR TRANSFORMATION.

DRAINAGE AREA = 1.3 SQUARE MILES

INFILTRATION DATA

INITIAL INFILTRATION = 1.5 inches

CONSTANT INFILTRATION 0.15 inches/hour

TIME OF CONCENTRATION (SCS-TR55)

1) OVERLAND FLOW L = 1700'
1040 - 915 = 125 SLOPE = 7.4%
CHANNEL FLOW L = 5000'
915 - 855 = 60' SLOPE = 1.2%
OVERLAND VELOCITY = 0.67 ft/sec
CHANNEL VELOCITY = 1.7 ft/sec

$$T_c = \left[\frac{1700}{0.67} + \frac{5000}{1.7}\right]\frac{1}{3600} = 0.70 + 0.82$$

T_c = 1.52 hours

TIME OF CONCENTRATION (con't)

2) BY KERBY HANDBOOK OF HYDROLOGY BY CHOW

$$T_c^{2.14} = \frac{2/3\, Ln}{\sqrt{S}}$$

where: T_c = overland time of concentration (min)
L = length of overland flow (ft.)
n = Mannings coeff. ($n = 0.4$)
S = slope (ft/ft.)

$$T_c^{2.14} = \frac{2/3\,(1700)0.4}{\sqrt{.0067}} = 5538$$

T_c = 55.2 minutes = 0.92 hours

TOTAL T_c = 0.82 + 0.92 = 1.74 hours

3) DESIGN OF SMALL DAMS pg 71

$$T_c = \left(\frac{11.9\,L^3}{H}\right)^{0.385}$$ where:

T_c = time of concentration (hours)
L = length of watercourse (miles)
H = elevation difference

L = 1.27 miles
H = 185'

$$T_c = \left(\frac{11.9(1.27)^3}{185}\right)^{0.385} = (0.13)^{.385} = 0.46$$

T_c = 0.46 hours

TIME OF CONCENTRATION (con't)

4) BY INTRODUCTION TO HYDROLOGY – VEISSMAN pg 135

$t_t = C_t (L L_{ca})^{0.3}$ where:

t_t = lag time (hours)

C_t = coefficient representing variations of watershed slopes ($C_t = 2.0$)

L = Length of main channel to divide (miles)

L_{ca} = Length along main channel to a point opposite the watershed centroid

$t_t = 2.0 (1.27 \times 0.32)^{0.3}$

LAG TIME = 1.53 hours

FOR COMPUTER INPUT

LAG TIME use t_c = 1.5 hours

LAG = 60% T_c = 0.9 hours

PRECIPITATION

Ref: Design of Small Dams, USDI, 1973

From Fig. 15 Zone 6:

PMP = 25 in / 6.0 hr. / 10 Sq. Mi.

Duration (hr.)	% PMP
6	100
12	109
24	117

STORCH ENGINEERS

Project KEMAH LAKE DAM

Sheet 4 of 12

Made By CLO Date 1/17/81

Chkd By JG Date 3/23/81

SQUARE 4 X 4 TO THE INCH

LAKE STORAGE VOLUME

WATER SURFACE ELEVATION	AREA (ACRES)
841	0
855	101.5
860	116.2
880	188.7
900	300.3

HEC-1-DAM COMPUTER PROGRAM WILL DEVELOP STORAGE CAPACITY FROM SURFACE AREAS AND ELEVATIONS.

INFORMATION TAKEN FROM USGS NEWTON NEST AND CULVERS GAP QUADRANGLES.

HYDRAULICS

THE SPILLWAY AT KEMAH LAKE DAM CONSISTS OF A NOTCHED CONCRETE WEIR WITH PROVISIONS FOR A STOPLOG IN THE NOTCH. THE SPILLWAY CAN FUNCTION EITHER AS A TWO STAGE WEIR (STOPLOG REMOVED) OR A ONE STAGE WEIR (STOPLOG IN PLACE). DOWNSTREAM FROM THE WEIR IS A 48-INCH DISCHARGE CULVERT. DISCHARGE WILL BE BASED ON WEIR FLOW OR CULVERT FLOW WHICHEVER CONTROLS. FOR WEIR FLOW, DISCHARGE Q, CAN BE CALCULATED BY:

$$Q = C L h^{3/2}$$

where;

Q = discharge over spillway
C = discharge coefficient
L = effective length of spillway
h = total head on spillway

Values for the discharge coefficient, "C" were taken from the "Handbook of Hydraulics" by King & Brater.

STORCH ENGINEERS

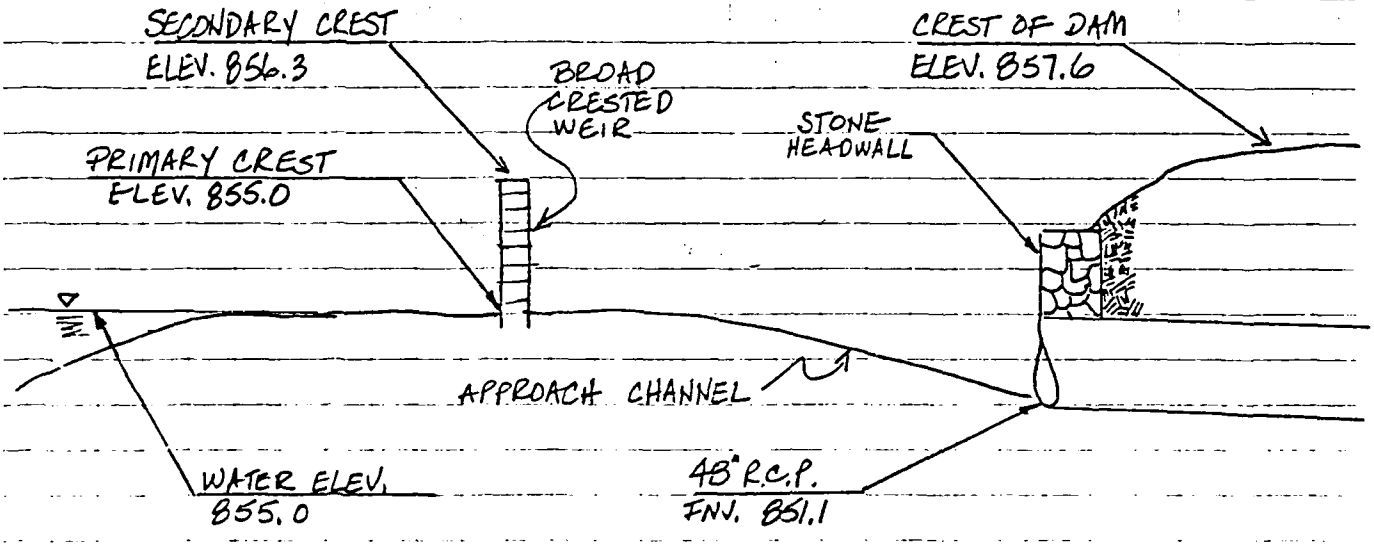
Project Kemaft Lake Dam

Sheet 6 of 12

Made By JLP Date 3-5-81

Chkd By JG Date 3/23/81

DISCHARGE Q, FOR THE 48" R.C.P. SPILLWAY WHICH PROTRUDES TRANSVERSELY THROUGH THE EMBANKMENT, WERE TAKEN FROM "HYDRAULIC CHARTS FOR THE SELECTION OF HIGHWAY CULVERT." FROM CHART 2 INLET CONTROL, AND GROOVE END PROJECTING.



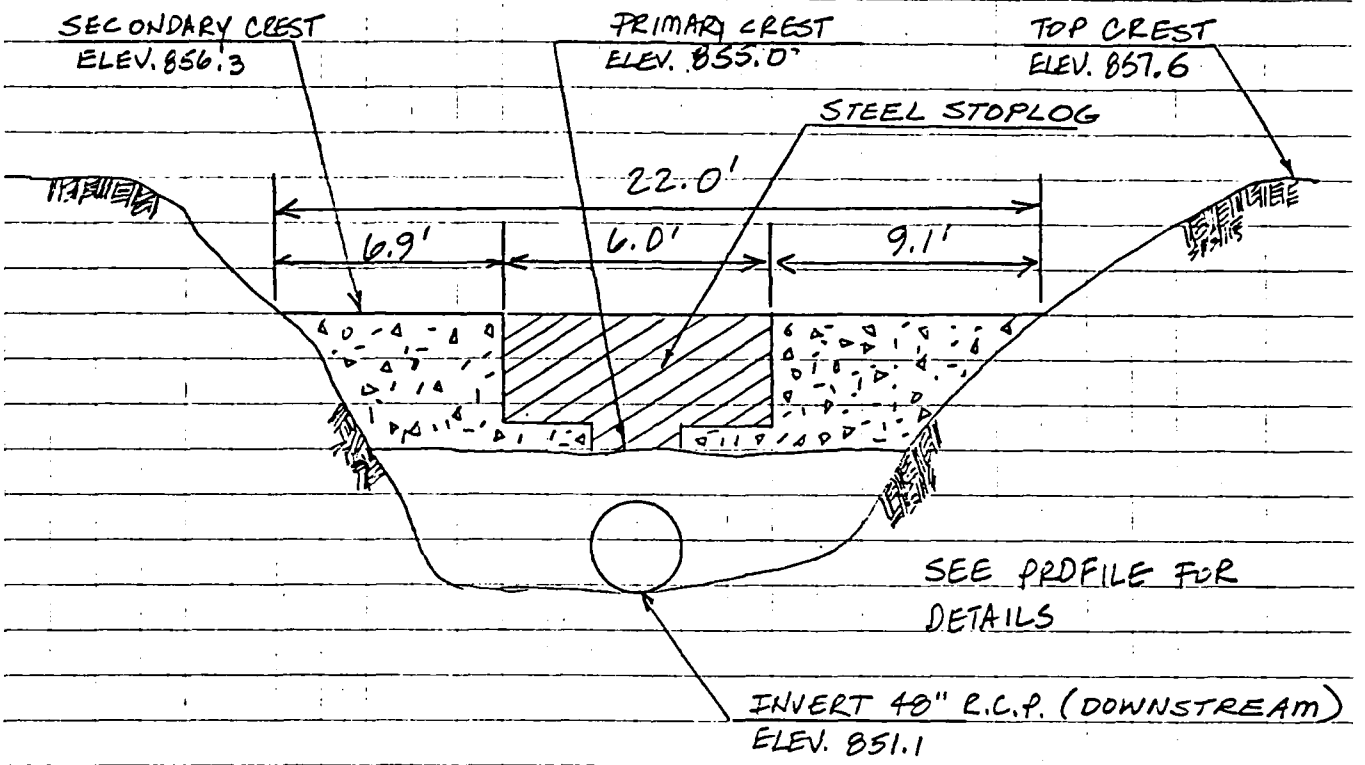
STORCH ENGINEERS

Project KEMAH LAKE Dam

Sheet 1 of 12

Made By JLP Date 3-4-81

Chkd By JG Date 3/23/81



SPILLWAY STAGE DISCHARGE TABULATION

(STOPLOG IN PLACE)

	PRINCIPAL SPILLWAY SECONDARY				48" R.C.P. INLET CONTROL	
ELEV.	C	L	H	Q	HW/D	Q
856.3	3.32	22.0		0		
857.0	3.32	22.0	0.68	40.9	1.47	110
857.6	3.32	22.0	1.24	100.9	1.6	120
858.0	3.32	22.0	1.68	159.0	1.725	128
859.0	3.32	22.0	2.68	319.5	1.975	140
860.0	3.32	22.0	3.68	515.6	2.225	152
861.0	3.32	22.0	4.68	739.5	2.375	160
862.0	3.32	22.0	5.68	988.7	2.725	180

STORCH ENGINEERS

Project KEMAH LAKE DAM

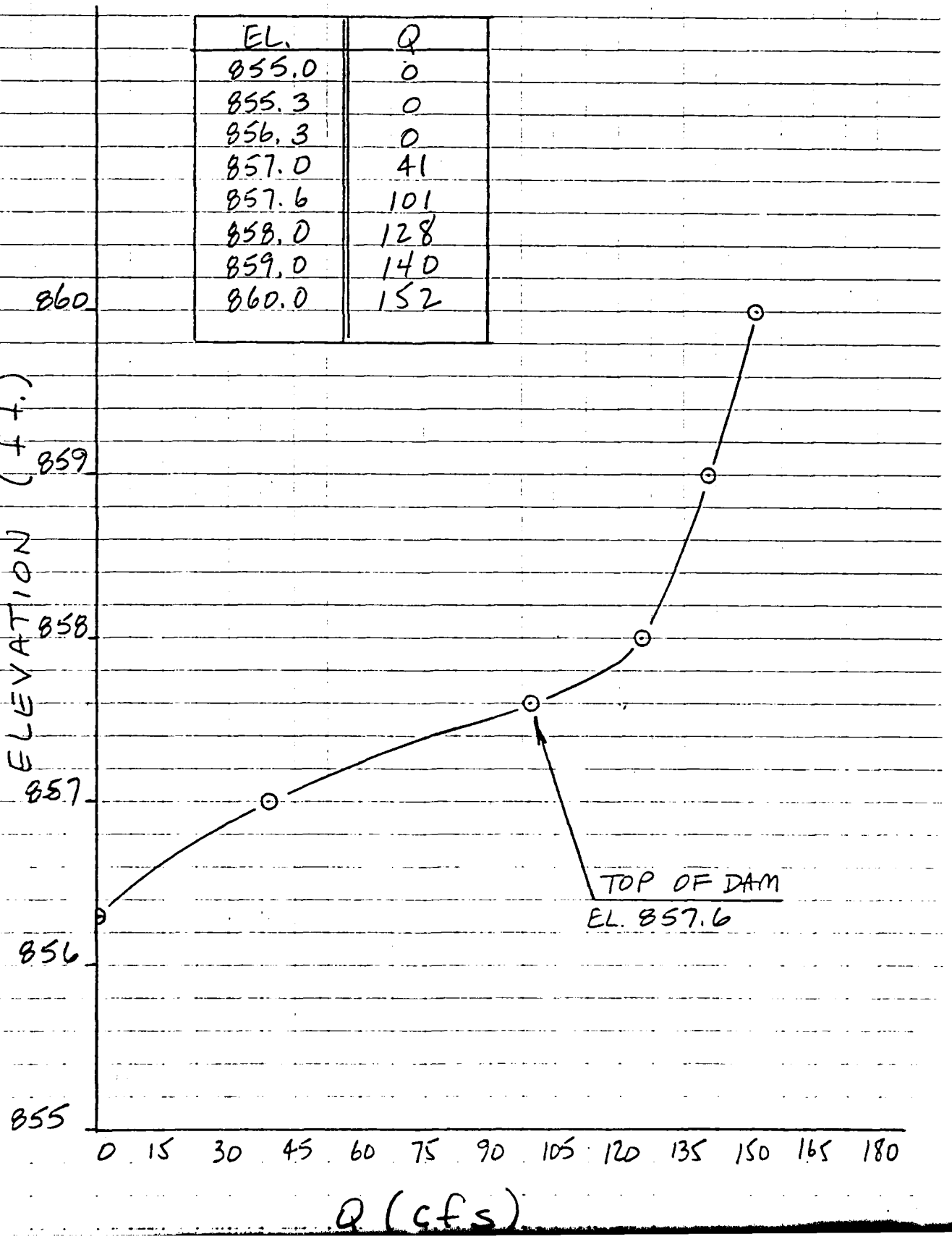
Sheet 5 of 12

Made By JLP Date 3-11-81

Chkd By JG Date 3/23/81

SPILLWAY STAGE-DISCHARGE CURVE

EL.	Q
855.0	0
855.3	0
856.3	0
857.0	41
857.6	101
858.0	128
859.0	140
860.0	152



STORCH ENGINEERS

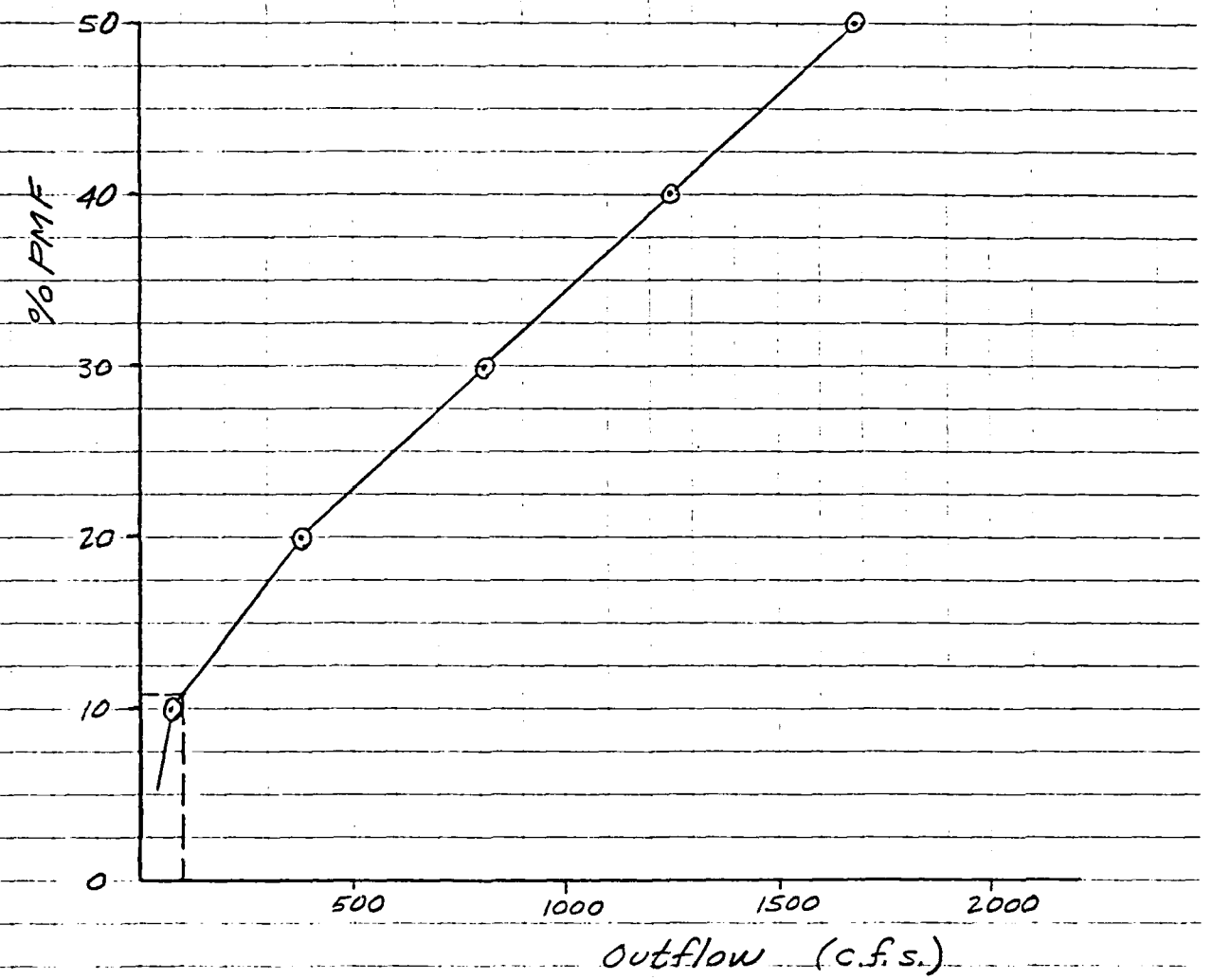
Sheet 9 of 12

Project KEMAH LAKE DAM

Made By JG Date 3/23/81

Chkd By _____ Date _____

OVERTOPPING POTENTIAL



Overtopping of dam occurs at elev. 857.6

with outflow Q = 101 c.f.s. (stoplog in place)

Dam can pass 11% PMF

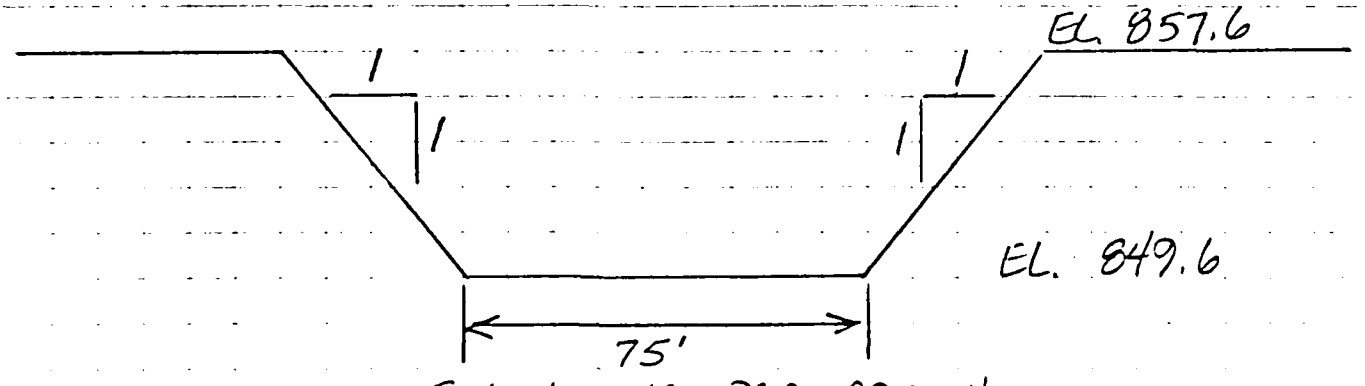
BREACH ANALYSIS

A BREACH HYDROGRAPH WILL BE COMPUTED BY THE HEC-1-DAM PROGRAM AND ROUTED THROUGH TWO DOWNSTREAM REACHES BY THE MODIFIED PULS METHOD. THE ASSUMED BREACH CONDITIONS ARE AS FOLLOWS:

1. THE BREACH BEGINS WHEN THE WATER SURFACE ELEVATION REACHES 857.6.

2. TIME TO DEVELOP BREACH = 1.0 HR.

3. SECTION:



FULLY DEVELOPED BREACH

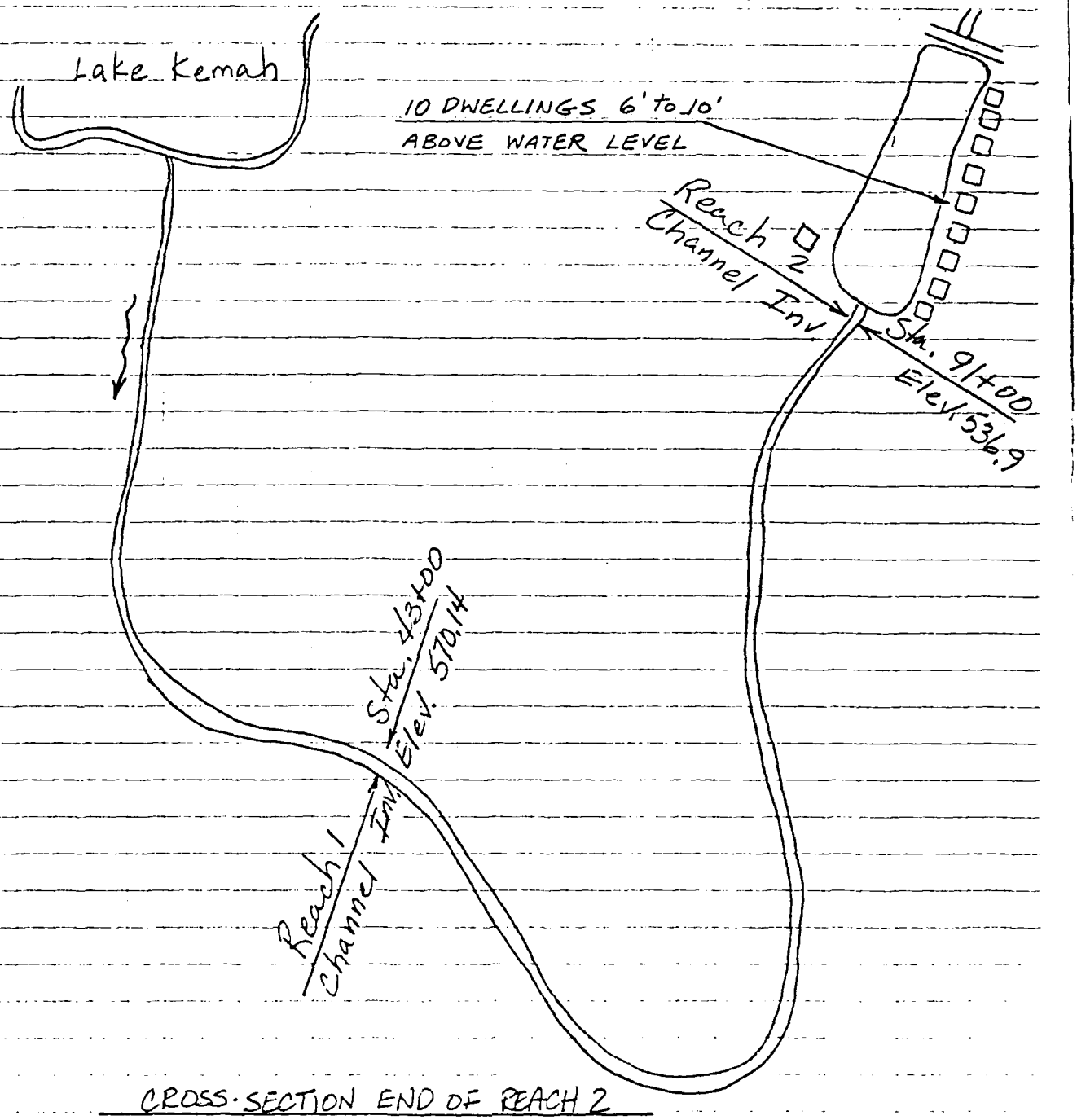
STORCH ENGINEERS

Sheet 11 of 12

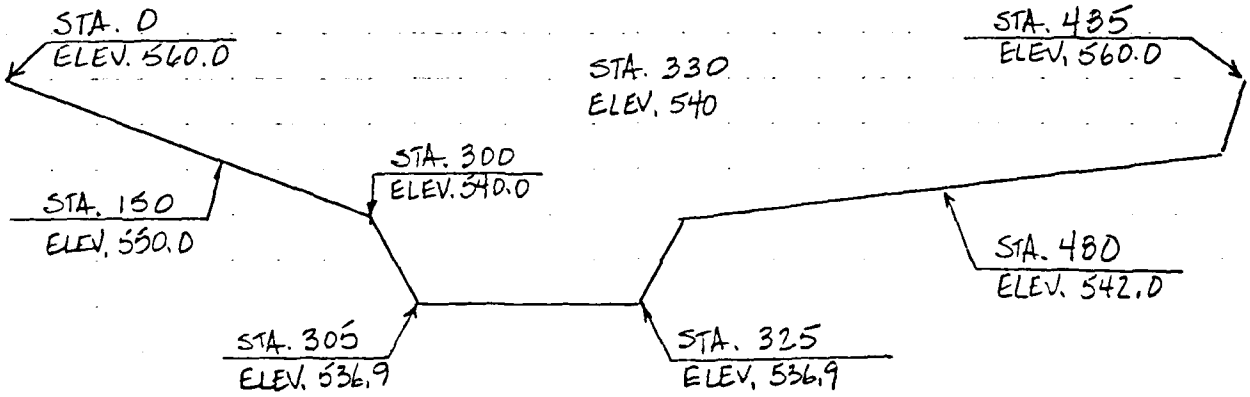
Project Kemah Lake Dam

Made By JLP Date 3-5-81

Chkd By JG Date 3/23/81



CROSS-SECTION END OF REACH 2



Project KEMAH LAKE DAM Made By JLP Date 3-5-81
Chkd By JG Date 3/23/81

BREACH RESULTS:

1. Peak Outflow = 12964 c.f.s.
2. Reach 1: MAX Stage Elev 577.4
   7.3' Above invert
3. Reach 2: MAX. Stage Elev. 547.6
   10.7' Above invert
4. LAKE : MAX Stage Elev 540.9
   9.3 ABOVE normal water level
   3 Dwellings inundated by 3.3'
   4 Dwellings inundated by 1.3'
   3 Dwellings not inundated
5. Without breach, max. stage of lake = 536.7; no dwellings inundated.

HEC - 1 - DAM PRINTOUT

Overtopping Analysis

```
1A1                          NATIONAL DAM SAFETY PROGRAM
A2                           KEMAH LAKE, NEW JERSEY
A3                           100 YEAR STORM ROUTING
B      60       0      30                                  0       0       4
B1      5
J       1       5       1
J1    0.5     0.4     0.3     0.2     0.1
K       0    LAKE                       0       0       1
K1         INFLOW HYDROGRAPH TO KEMAH LAKE DAM
M       1       2     1.3             1.3       0                       1
P       0      25     100     109     117
T                                                     1.5    0.15
W2             0.9
X    -1.0   -0.05     2.0
K       1     DAM
K1         ROUTE DISCHARGE THROUGH DAM
Y                                     1       1
Y1      1                                          -856.3      -1
Y4  855.0   855.3   856.3   857.0   857.6   858.0   859.0   860.0   861.0   862.0
Y5      0       0       0    40.9   100.9     128     140     152     160     180
$A      0   101.5   116.2   188.7   300.3
$E    841     855     860     880     900
$$  856.3
$D  857.6    2.63     1.5     290
K       1       1                                     1
K1      CHANNEL ROUTING REACH 1
Y                                     1       1
Y1      1
Y6    0.1   0.035     0.1   570.1     580    4300   0.065
Y7      0     580     100     575     198     572     200   570.1     220   570.1
Y7    222     572     275     575     285     580
K       1       2                                     1
K1         CHANNEL ROUTING REACH 2
Y                                     1       1
Y1      1
Y6    0.1   0.035     0.1   536.9     560    4800   0.007
Y7      0     560     150     550     300     540     305   536.9     325   536.9
Y7    330     540     480     542     485     560
K       1  UN DAM
K1         ROUTE DISCHARGE THRU UNKNOWN DAM
Y                                     1       1
Y1      1                                          -532.0      -1
Y4    532     533     534     536     538     540     544     548
Y5      0      26      75     146     189     224     280     327
$A      0    13.8    23.0    95.0
$E    523     532     540     550
$$    532
$D    535    2.63     1.5     250
K      99
```

HYDROGRAPH ROUTING

ROUTE DISCHARGE THROUGH DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
DAM	1	0	0	0	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-856.	-1

STAGE	855.00	855.30	856.30	857.00	857.60	858.00	859.00	860.00	861.00	862.00
FLOW	0.00	0.00	0.00	40.90	100.90	128.00	140.00	152.00	160.00	180.00
SURFACE AREA=	0.	102.	116.	189.	300.					
CAPACITY=	0.	474.	1018.	4037.	8884.					
ELEVATION=	841.	855.	860.	880.	900.					

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
856.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
857.6	2.6	1.5	290.

PEAK OUTFLOW IS 1692. AT TIME 17.50 HOURS

NATIONAL DAM SAFETY PROGRAM
KEMAH LAKE, NEW JERSEY
100 YEAR STORM ROUTING

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
60	0	30	0	0	0	0	0	4	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 5 LRTIO= 1
RTIOS= .50 .40 .30 .20 .10

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO KEMAH LAKE DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
LAKE	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	1.30	0.00	1.30	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.00	100.00	109.00	117.00	0.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.50	.15	0.00	0.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .90

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 2.00

0
END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	23.40	19.63	3.77	35160.
										(594.)	(499.)	(96.)	(995.62)

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS				
				RATIO 1 .50	RATIO 2 .40	RATIO 3 .30	RATIO 4 .20	RATIO 5 .10
HYDROGRAPH AT	LAKE	1.30	1	2383.	1906.	1430.	953.	477.
		(3.37)	(	67.47)(	53.97)(	40.48)(	26.99)(	13.49)(
ROUTED TO	DAM	1.30	1	1692.	1245.	806.	383.	76.
		(3.37)	(	47.92)(	35.27)(	22.82)(	10.84)(	2.15)(
ROUTED TO	1	1.30	1	1689.	1234.	806.	378.	76.
		(3.37)	(	47.84)(	34.95)(	22.82)(	10.72)(	2.16)(
ROUTED TO	2	1.30	1	1642.	1210.	786.	377.	76.
		(3.37)	(	46.49)(	34.25)(	22.25)(	10.67)(	2.14)(
ROUTED TO	UN DAM	1.30	1	1611.	1196.	788.	312.	56.
		(3.37)	(	45.62)(	33.87)(	22.31)(	8.83)(	1.58)(

SUMMARY OF DAM SAFETY ANALYSIS

.....		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	856.30	856.30	857.60
	STORAGE	608.	608.	747.
	OUTFLOW	0.	0.	101.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	859.20	1.60	926.	1692.	12.00	17.50	0.00
.40	858.88	1.28	889.	1245.	11.00	17.50	0.00
.30	858.52	.92	849.	806.	9.00	18.00	0.00
.20	858.08	.48	800.	383.	7.00	18.50	0.00
.10	857.35	0.00	720.	76.	0.00	19.50	0.00

PLAN 1 STATION 1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	1689.	573.3	17.50
.40	1234.	572.8	17.50
.30	806.	572.3	18.00
.20	378.	571.5	18.50
.10	76.	570.6	19.50

PLAN 1 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	1642.	542.1	18.00
.40	1210.	541.5	18.00
.30	786.	540.7	18.50
.20	377.	539.5	18.50
.10	76.	537.8	20.00

SUMMARY OF DAM SAFETY ANALYSIS

.....		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	532.00	532.00	535.00
	STORAGE	41.	41.	87.
	OUTFLOW	0.	0.	111.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	536.69	1.69	118.	1611.	10.50	18.00	0.00
.40	536.36	1.36	112.	1196.	10.00	18.50	0.00
.30	535.98	.98	105.	788.	8.00	18.50	0.00
.20	535.43	.43	95.	312.	5.50	20.00	0.00
.10	533.61	0.00	65.	56.	0.00	26.00	0.00

HEC - 1 - DAM PRINTOUT

Breach Analysis

```
1A1                         NATIONAL DAM SAFETY PROGRAM
A2                          KEMAH LAKE, NEW JERSEY
A3                          100 YEAR STORM ROUTING
B     60       0       30                                    0       0       4
B1     5
J      1       5       1
J1   0.5     0.4     0.3     0.2     0.1
K      0    LAKE                       0       0       1
K1        INFLOW HYDROGRAPH TO KEMAH LAKE DAM
M      1       2     1.3               1.3     0                               1
P      0      25     100     109       117
T                                                   1.5     0.15
W2           0.9
X   -1.0   -0.05     2.0
K      1     DAM
K1        ROUTE DISCHARGE THROUGH DAM
Y                                 1       1
Y1     1                                            -856.3      -1
Y4 855.0   855.3   856.3   857.0   857.6   858.0   859.0   860.0   861.0   862.0
Y5     0       0       0    40.9   100.9     128     140     152     160     180
$A     0   101.5   116.2   188.7   300.3
$E   841     855     860     880     900
$$ 856.3
$D 857.6    2.63     1.5     290
$B    75       1     841     1.0   856.3   857.6
K      1       1                                       1
K1       CHANNEL ROUTING REACH 1
Y                                 1       1
Y1     1
Y6   0.1   0.035     0.1   570.1     580    4300   0.065
Y7     0     580     100     575     198     572     200   570.1     220   570.1
Y7   222     572     275     575     285     580
K      1       2                                       1
K1       CHANNEL ROUTING REACH 2
Y                                 1       1
Y1     1
Y6   0.1   0.035     0.1   536.9     560    4800   0.007
Y7     0     560     150     550     300     540     305   536.9     325   536.9
Y7   330     540     480     542     485     560
K      1    UN-DAM
K1       ROUTE DISCHARGE THRU UNKNOWN DAM
Y                                 1       1
Y1     1                                            -532.0      -1
Y4   532     533     534     536     538     540     544     548
Y5     0      26      75     146     189     224     280     327
$A     0    13.8    23.0    95.0
$E   523     532     540     550
$$   532
$D   535    2.63     1.5     250
K     99
```

HYDROGRAPH ROUTING

ROUTE DISCHARGE THROUGH DAM

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	DAM	1	0	0	0	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

	NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
	1	0	0	0.000	0.000	0.000	=856.	-1

STAGE	855.00	855.30	856.30	857.00	857.60	858.00	859.00	860.00	861.00	862.00
FLOW	0.00	0.00	0.00	40.90	100.90	128.00	140.00	152.00	160.00	180.00
SURFACE AREA=	0.	102.	116.	189.	300.					
CAPACITY=	0.	474.	1018.	4037.	8884.					
ELEVATION=	841.	855.	860.	880.	900.					

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
856.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
857.6	2.6	1.5	290.

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
75.	1.00	841.00	1.00	856.30	857.60

BEGIN DAM FAILURE AT 15.50 HOURS

PEAK OUTFLOW IS 12964. AT TIME 16.50 HOURS

NATIONAL DAM SAFETY PROGRAM
KEMAH LAKE, NEW JERSEY
100 YEAR STORM ROUTING

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
60	0	30	0	0	0	0	0	4	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 5 LRTIO= 1

RTIOS=	.50	.40	.30	.20	.10

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO KEMAH LAKE DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
LAKE	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	1.30	0.00	1.30	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.00	100.00	109.00	117.00	0.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.50	.15	0.00	0.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .90

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 2.00

0
END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	23.40	19.63	3.77	35160.
										(594.)	(499.)	(96.)	(995.62)

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS				
				RATIO 1 .50	RATIO 2 .40	RATIO 3 .30	RATIO 4 .20	RATIO 5 .10
HYDROGRAPH AT	LAKE	1.30	1	2383.	1906.	1430.	953.	477.
		(3.37)	(	67.47)(	53.97)(	40.48)(	26.99)(	13.49)(
ROUTED TO	DAM	1.30	1	12964.	12452.	12487.	11827.	76.
		(3.37)	(	367.09)(	352.60)(	353.60)(	334.90)(	2.15)(
ROUTED TO	1	1.30	1	12065.	11557.	11693.	11043.	76.
		(3.37)	(	341.65)(	327.26)(	331.12)(	312.71)(	2.16)(
ROUTED TO	2	1.30	1	10538.	9932.	9566.	8779.	76.
		(3.37)	(	298.40)(	281.23)(	270.88)(	248.61)(	2.14)(
ROUTED TO	UN DAM	1.30	1	10566.	10028.	9850.	9135.	56.
		(3.37)	(	299.21)(	283.96)(	278.93)(	258.68)(	1.58)(

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	856.30	856.30	857.60
STORAGE	608.	608.	747.
OUTFLOW	0.	0.	101.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	857.96	.36	786.	12964.	.92	16.50	15.50
.40	857.67	.07	755.	12452.	.78	16.50	15.50
.30	858.02	.42	794.	12487.	.94	17.50	16.50
.20	857.78	.18	767.	11827.	.82	18.00	17.00
.10	857.35	0.00	720.	76.	0.00	19.50	0.00

PLAN 1 STATION 1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	12065.	577.4	16.50
.40	11557.	577.3	16.50
.30	11693.	577.3	17.50
.20	11043.	577.1	18.00
.10	76.	570.6	19.50

PLAN 1 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	10538.	547.6	17.00
.40	9932.	547.3	17.00
.30	9566.	547.2	18.00
.20	8779.	546.8	18.50
.10	76.	537.8	20.00

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	532.00	532.00	535.00
STORAGE	41.	41.	87.
OUTFLOW	0.	0.	111.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	541.27	6.27	220.	10566.	6.50	17.00	0.00
.40	541.05	6.05	214.	10028.	5.50	17.00	0.00
.30	540.98	5.98	212.	9850.	4.50	18.00	0.00
.20	540.68	5.68	204.	9135.	3.50	18.50	0.00
.10	533.61	0.00	65.	56.	0.00	26.00	0.00

APPENDIX 5

Bibliography

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